

Lab Course in Cardiac Physiology
HAPS Institute Graduate Credit Course
offered in conjunction with Alverno College
January 17– March 7, 2018.

Instructor:

Patrick Eggena, M.D.
Novateur Medmedia, LLC
39 Terry Hill Road
Carmel, NY 10512
patrickeggena@yahoo.com

Class size: 2-24 students.

Description of this Course:

In this 1 credit course participants attend live one-hour sessions each week in a *Google Meet* classroom on Wednesdays at 3:00 p.m. EST. During these sessions they project their EKGs onto their mobile phone or iPad screens using an inexpensive *Kardia Mobile* recorder with an App.

Participants measure their mean QRS axis and relate their EKGs to their heart sounds, blood pressure, pulse, ventricular blood volumes and cardiac action potentials.

In this way participants generate *pressure-EKG (time)*, *volume-EKG (time)* and *work diagrams* for their cardiac cycles at rest and during exercise.

Having completed these experiments on themselves, participants engage in a lively conversation as they apply the physiological principles they have just learned as they follow in the footsteps of Dr. Eggena who leads them through seven episodes of his “Country Doctor” series in Apple iBooks.

Although this course is constructed so that each participant can experiment on him or herself, this course may also be implemented by three or four students from the same institution performing the experiments and discussing the cases as a team before coming to the weekly sessions with Dr. Eggena.

Identification of course outcomes:

Participants will be able to

- 1) --distinguish a normal from an abnormal EKG in a patient complaining of chest pain.
- 2) --relate their EKG at rest and with exercise to their heart sounds, volumes and pressures in their left ventricle and aorta during the cardiac cycle.

- 3) –calculate the work of their left ventricle at rest and with exercise, given normal resting values for cardiac index and ejection fractions.
- 4) --appreciate the relationship between venous return, cardiac output, and atrial pressure at rest and with exercise..

Evaluation

Student performance is evaluated by Dr. Eggena on the basis of his/her participation in the seven laboratory/discussion sessions and on the reports of their personal *pressure-EKG (time) and volume-EKG (time) graphs, and their pressure-volume work diagrams and their graphic analysis of cardiac output and venous return* at rest and with exertion.

All HAPS-I courses follow grading policies on a "credit / no credit" basis. Like many progressive graduate programs, HAPS-I does not use letter grades in our courses. However, a "credit" grade is equivalent to a letter grade of B or better. A "credit" grade is earned by satisfactorily accomplishing a set of specific goals (at a "B" level or better) as outlined in this course syllabus and in the online course material as determined by the course faculty.

Course Schedule: January 17 – February 28, 2018.

Syllabus

Participants prepare for this laboratory course by viewing the video lectures by Dr. Eggena in his seven episodes as a Country Doctor. This provides the necessary physiology background for the experiments and case discussions starting at the beginning of the course on January 17th.

In the week prior to the live session in the “Google Meet” classroom, participants perform the experiments on themselves, read the case, and answer the questions in the syllabus in preparation for the laboratory/case review session with Dr. Eggena.

Participants from the same institution should organize themselves into teams of three or four students to carry out these experiments and discuss the cases in a small group setting before coming to the review sessions.

Each session has a different link, which is needed to gain access to the classroom. Moreover, the “Google Chrome” browser is required. It may be downloaded for free from the internet. The links will be emailed to participants.

Wednesday, January 17, 2018, 3:00 p.m. EST Google Meet Classroom.

(1) Experiment: Your waves and intervals on the Kardia Mobile EKG

(a) Place the EKG disc close (<30 cm) to your iPhone (of iPad or other compatible mobile phone) on a table in front of you. Make sure it has the proper orientation, i.e., with the Kardia logo in the center. Draw a “positive” (+) sign with a marker pen on the left square (positive pole of Lead I) and a “negative” (-) sign on the right square (negative pole of Lead I).

(b) Place the index and middle finger of your left hand on the positive pole and the fingers of your right hand on the negative pole, and begin recording your EKG with Einthoven’s standard Lead I.

(2) Questions

1. What do the various waves represent?
2. What are the durations of your P-R, QRS, and R-R intervals and what do they represent?
3. Give example when the intervals will be prolonged.
4. How long is your heart in systole and in diastole?
5. What is the length of your QT and QTc intervals?
6. What is the significance of a prolonged QTc interval?
7. Make a copy of your EKG, enlarge it, and paste it on a sheet of paper. Using your EKG as a marker for time, draw above your EKG the cardiac action potentials of your SA and AV nodes and of a ventricular muscle cell. Describe the different phases of the action potentials and the ionic fluxes responsible for them.

January 24th- 3:00 p.m. EST.

(1) Experiment: Your mean QRS axis with the Kardia Mobile EKG recorder.

To obtain your EKG with Einthoven’s standard Lead II, place the Kardia disc close to your iPhone on the floor. Leaning forward from a low stool, place your left big toe on the positive pole of the disc and your two fingers from your right hand (as before) on the negative pole. This should generate an EKG tracing similar to Lead II of a standard 12 lead EKG machine.

- (a) Using your recordings from Leads I and II, determine your mean QRS axis.
- (b) Draw the changes in your QRS waves you would expect to see if you were to develop right or left axis deviation. When might you see this?

(2) Episode 2: The Veteran with PTSD.

This veteran complains of a “broken heart”. Examine his 12-lead EKG and answer the following questions:

1. What is his rhythm?
2. What is his rate?
3. Where is his pacemaker?
4. Any conduction delays?
5. What is his mean QRS axis?
6. Are his atria hypertrophied?
7. Are his ventricles hypertrophied?
8. Is there any evidence for myocardial ischemia?
9. Is there any evidence for myocardial injury?
10. Any evidence for myocardial infarction?

January 31st – 3:00 p.m. (EST)

(1) Experiment: Cardiac Cycle at rest and with exercise.

- (a) Using your right hand, place the EKG disc in your left axilla at the approximate position for precordial lead V6. We will call this your “axillary” EKG.
Place a blood pressure cuff around your left arm and move your chest to a position close enough to the edge of a table for generating a signal on your iPad. Now measure your EKG and blood pressure simultaneously at rest.
- (b) Repeat the above experiment, but now exercise, e.g., by rapidly moving up two steps and back down, until your pulse (as measured with your pulse oximeter attached to a finger on your right hand) reaches about 50% of your maximal pulse rate, which equals $220 \text{ bpm} - \text{your age}$.
- (c) Assuming that your aortic and brachial artery pressures are equal with no resistance at the aortic valve, plot the changes in your aortic and ventricular pressures (y-axis) as a function of your EKG (x-axis). (Enlarge your EKG tracing or redraw it in order to expand the x-axis.)
- (d) Label the points where your aortic and mitral valves open and close, and the periods of isovolumic contraction and relaxation.
- (e) Measure and compare the P-R, QT, QTc, and R-R intervals at rest and with exercise.

- (f) Compare the duration of systole and diastole at rest and with exercise, and consider how you are compensating for the shorter time allotted for your cardiac cycle with exercise.

(2) Episode 1: The girl with the fast heart beat.

A girl suddenly feels her heart racing. Her EKG shows normal QRS complexes two large EKG boxes apart. She has paroxysmal supraventricular tachycardia (PSVT),

- (a) at a rate of _____?
- (b) What may have been responsible for her PSVT?
- (c) What changes in the action potential of her AV node will you make in an attempt to revert her PSVT back to a normal sinus rhythm?
- (d) Given equivalent heart rates with exercise before and during her PSVT compare her relative cardiac outputs under these circumstances and consider the reasons for this difference.
- (e) Why did she feel faint and have trouble breathing with her PSVT?

February 7th – 3:00 p.m. (EST)

(1) Experiment: Volume changes during your Cardiac Cycle at rest

Using the data from last week's session (i.e., EKG, blood pressure, and pulse) and assuming a normal cardiac index of 3.3 L/min/meter squared and a normal ejection fraction of 0.60, calculate your cardiac output, stroke volume, end-systolic and end-diastolic volumes. Make a plot depicting your left ventricular volume changes (y-axis) as a function of your EKG (x-axis).

(2) Episodes 3 and 4: The Farmer with a Heart Attack.

A farmer complaining of chest pain has EKG and cardiac enzyme findings that are consistent with an acute myocardial infarction.

1. What causes his "angina pectoris"?
2. Why is he given nitroglycerine?
3. Why did morphine help his condition?
4. Which hormones will be elevated in his circulation and how will they help his condition?

5. What is the coronary steal phenomenon and how can it be prevented?
6. What are you going to do for his ventricular fibrillation?
7. How does a shock sometimes revert ventricular fibrillation to a normal rhythm?
8. Why use epinephrine, amiodarone, and lidocaine in between shocks and CPR during cardiac resuscitation?

February 14th - 3:00 p.m. (EST)

(1) Experiment: Heart Sounds

Measure your “axillary” EKG with your right hand while simultaneously listening to your heart with a stethoscope in your left hand. Mark the points on your EKG where you hear first and second heart sounds. Add these points to your graph of January 31st above.

Also indicate the points where you would hear –in a patient -- a 3rd and 4th heart sound, and explain the causes for these abnormal gallop sounds.

(2) Episode 5: The Lady with Atrial Fibrillation.

- (a) How could you suspect that she had atrial fibrillation before taking her EKG?
- (b) Why did she have a stroke?
- (c) Given equal pulse rates with exercise or atrial fibrillation, why is her cardiac output with atrial fibrillation lower than it is with exercise?
- (d) How could you alter phase 0 of her AV nodal action potential to decrease her heart rate below 100 bpm?
- (e) Why could she not breathe sleeping without several pillows?
- (f) Why were her feet swollen?

February 21st - 3:00 p.m. (EST)

(1) Experiment: The Work of your Left Ventricle during a Cardiac Cycle at rest and with exercise.

Using the data you have collected at rest, and assuming an end-systolic pressure of 3 mmHg and end-diastolic pressure of 7 mmHg, make a plot of pressure (y-axis) as a function of left ventricular volume (x-axis) during one of your cardiac cycles.

Using previously measured data on yourself during exercise and adding new cardiac output estimates based upon changes in pulse

pressure and heart rate, plot your pressures as function of left ventricular volumes. Compare the work performed by your left ventricle before and after exercise and discuss the ATP (and coronary blood) requirements with “pressure” versus “volume” work.

(2) **Episode 6:** A woman in Intensive Care with a Swan-Ganz Catheter.

This discussion centers around measuring cardiac output and pulmonary artery wedge pressures (PAWP) of a woman in cardiogenic shock following a heart attack.

- (a) What is “heart failure”?
- (b) How is cardiac output measured with a Swan-Ganz catheter?
- (c) What caused her “tachycardia”?
- (d) Why was she “diaphoretic”?
- (e) Why did she have 3rd and 4th heart sounds?
- (f) Why was she “dyspneic”?

February 28th - 3:00 p.m. (EST)

(1) **Experiment:** The relationship between Cardiac Output, Venous Return, and Atrial Pressure at rest and with exercise.

Using the data you have collected on yourself make a plot of cardiac output and venous return (y-axis) as a function of central venous pressure (CVP, x-axis). Your CVP (in cm H₂O) is the vertical distance (in cm) between the maximal filling point of your external jugular veins and your tricuspid valve (at the level of the 4th intercostal space, mid-axillary line) with your upper body at an angle of 30 degrees relative to the floor.

- (a) What is your cardiac reserve?
- (b) What would your CVP be if you were exercising and had no cardiac reserve because of a “heart condition”?
- (c) What would your PAWP be if you replaced your CVP with a PAWP value 5 mmHg higher in your graph in order to illustrate the situation in your left ventricle?
- (d) What would your symptoms be? Explain !

(2) **Episode 7:** A pregnant woman with mitral stenosis.

A woman in her third trimester of pregnancy can't catch her breath, is coughing up blood, and has a heart murmur.

- (a) Using a copy of one of your “axillary” EKGs, draw the phonocardiogram of the murmurs you are hearing in the lady with mitral stenosis.
- (b) Although she has had mitral stenosis from childhood, only now -- during her third trimester of pregnancy – is she “dyspneic”. Why?
- (c) Why is she coughing up blood?

March 7th

Deadline for submission of graphs via email to patrickeggna@yahoo.com for evaluation for course credit.

Required Course Materials:

a) Equipment (current prices)

- 1) Kardia Mobile EKG recorder (\$99 on Amazon) with App compatible with participant’s mobile phone or iPad.
- 2) Automatic arm blood pressure apparatus (~\$40)
- 3) Stethoscope (~\$15)
- 4) Pulse oximeter (~\$16)

b) Video and Reading Programs

- 1) “Cardiac Physiology as a Country Doc”, Novateur Medmedia LLC by Patrick Eggena, M.D. – Apple iBooks, seven episodes (ea- \$3.99).
- 2) “Medical Physiology of the Heart-Lung-Kidney”, Novateur Medmedia LLC by Patrick Eggena, M.D. –Apple iBooks (\$14.99).

