

Experiment HH-2: The Electrocardiogram and Heart Sounds

[Instructor edits are in bright red type]

Background

Blood enters the arterial system from the ventricles of the heart in a pulsatile manner. However, when blood is leaving the arterial system through the capillaries, it flows in a continuous manner. Between contractions, when the heart is relaxed and blood is not being pumped into the arterial system, there is still enough pressure in the arterial system to move blood along the arteries. The pressure in the arterial system exists because the elasticity of the arteries allows them to distend and recoil and function as a pressure reservoir.

When the ventricles contract, the pressure of the blood inside the ventricles increases to close the atrioventricular valves. Further contraction increases the ventricular pressure until it exceeds the arterial pressure. At this point, when the arterial pressure is at its lowest point during the cardiac cycle (called diastolic pressure), the semilunar valves are forced open and blood flows into the arteries. Blood entering the arterial system inflates the arteries a little and increases blood pressure to a maximum, which is the systolic pressure.

In this lab you will record the ECG from a subject and listen to the characteristic "lub-dub" heart sounds. The "lub" sound occurs during the early phase of ventricular contraction and is produced by closing of the atrioventricular valves, which prevents blood flowing back into the atria. When the ventricles relax, the blood pressure drops below what is in the artery and the semilunar valves close, producing the "dub" sound.

Equipment Required

Same as HH-1, except remove the PT-104 Pulse plethysmograph and add:
EM-100 Event marker

IWX/214 Setup - completed in Experiment HH-1

Start the Software - see Syllabus, Appendix 2

- 1 Close the HH-1 data file and PDF. Click LabScribe on the desktop to reopen the program if necessary.
- 2 Pull down the **Settings** menu, select **Load Group**, then **Settings**, and **IPLMv4.iwxgrp**. Click *Open*.
- 3 Pull down the **Settings** menu again. Select **Human Heart** and then open the **ECG-HeartSounds-LS2** settings file. The PDF file which appears may be printed and used as an alternative to this edited file.
- 4 The settings used to configure the LabScribe software and the IWX/214 unit for this experiment are listed in Table HH-2-1 (shown in the LabScribe PDF).

ECG Cable and Event Marker Setup

- 1 Keep the C-AAMI-504 ECG cable and electrode lead wires connected to each other and to the IWX/214, as shown in Figure HH-2-3, below.

- 2 Plug the DIN8 connector of the EM-100 event marker (Figure HH-2-2, below) into the Channel 3 input of the IWX/214 (Figure HH-2-3).



Figure HH-2-2: The EM-100 event marker.



Figure HH-2-3: The ECG cable and event marker connected to an IWX/214.

- 3 The subject should remove jewelry, place electrodes as described for HH-1 (avoiding contact with clothing), and avoid movement during the recording.

Exercise 1: The ECG in a Resting Subject

Aim: To measure the ECG in a resting individual.

Procedure

- 1 Assuming that the subject did not move during the recording in Experiment HH-1, the data from the ECG channel of HH-1 Exercise 1 can be used for the following data analysis. If you wish, you may record additional data as described in the revised file for HH-1. To conserve time and electrodes, only record additional data if it is necessary.
- 2 Invert, if necessary, and save, but do not close the file if you record new data. Continue to the next exercise, and perform the following data analyses only after all experiments have been completed.

Data Analysis

- 1 Scroll through the recording and find a section of data with four to six good ECG cycles in succession. Ideally, you will use the same section of data as in HH-1, and perform the analysis at the same time.
- 2 Adjust the display time of the **Main** window to show at least four complete ECG cycles. Transfer the data to the **Analysis** window. The trace on the ECG channel (upper channel of Figure HH-1-5) may be expanded to facilitate the analysis.

3 Use the mouse to click on and drag the cursors to specific points on the ECG recording to measure the following:

- The **R wave amplitude**. Place one cursor on the **isoelectric line (baseline just prior to the Q wave that precedes the R wave)** and the second cursor on the peak of the R wave. The value for **V2-V1** on the **ECG** channel is the **R wave** amplitude. Measure the amplitudes of two additional R waves. **Note that Figure HH-2-5 of the LabScribe PDF was not available for presentation here, but it shows a cursor on the Q wave. Please disregard that figure and make the measurement as described here.**
Results (with units): _____

- The **P wave amplitude**. Place one cursor on the baseline that precedes the P wave and the second cursor on the peak of the P wave. The value for **V2-V1** on the **ECG** channel is the **P wave** amplitude. Measure the amplitudes of two additional P waves.
Results (with units): _____

- The **T wave amplitude**. Place one cursor on the baseline that precedes a P wave and the second cursor on the peak of the T wave that is in the same cycle as that P wave. The value for **V2-V1** on the **ECG** channel is the **T wave** amplitude. Measure the amplitudes of two additional T waves.
Results (with units): _____

- The **beat period**, which is the time interval between two adjacent R waves. To measure the beat period, place one cursor on the peak of an R wave and the second cursor on the peak of the adjacent R wave. The value for **T2-T1** on the **ECG** channel is the beat period. Measure the beat period for two additional pairs of R waves.
Results (with units): _____

Note that we could measure the P-Q, Q-T and T-Q intervals, in addition to the R-R interval (see Stanfield and Germann, Fig. 13.16). Such measurements would strengthen a scientific paper on this topic, but they are not required for the laboratory report this week. We will measure those intervals later in the semester (Experiment HH-3).

4 Calculate the following values and report them below (required) and in the Journal (optional):

- The average amplitudes (with units) of the:
P wave _____ R wave _____ and
T wave _____.

- The average beat period, in seconds/beat: _____

- The heart rate, which is expressed in beats per minute and calculated from the average beat period by using the following equation:

$$\text{Heart Rate (BPM)} = \frac{60 \text{ secs/minute}}{(\times \text{ seconds/beat})}$$

Heart rate: _____ beats/min.

Questions

- 1 Is the amplitude of each wave (P, QRS, T) always the same in different cardiac cycles? _____
- 2 Which wave has the largest amplitude? _____

Exercise 2: ECG Recordings from Other Subjects

Aim: To measure heart rate from other students.

Procedure

- 1 If good ECG cycles were obtained for the second subject in Experiment HH-1, then proceed directly to Exercise 3 and perform the following data analysis later. If you need to record additional data for the second subject, then disconnect the lead wires from the wrists and ankle of the first subject. Place new ECG electrodes on another subject and record the ECG as described in Exercise 1. At the beginning of each recording, type the name of the subject in the **Mark** box and click **Enter** to mark the recording.

Data Analysis

Measure the amplitudes of the ECG waves and beat periods of the second subject using the same techniques used in the analysis section of Exercise 1.

R wave amplitude:

Results (with units): _____

Average with units): _____

P wave amplitude:

Results (with units): _____

Average with units): _____

T wave amplitude:

Results (with units): _____

Average with units): _____

Beat period:

Results (with units): _____

Average with units): _____

Heart rate: _____ beats/min.

Questions

- 1 Do the P waves of different subjects have the same amplitude? _____ The QRS complexes? _____ The T waves? _____ Why? _____
- 2 For each subject, determine the wave with the largest amplitude. **Subject 1:** _____ **Subject 2:** _____ Is this result the same for all individuals? _____
- 3 Is the heart rate the same for each individual? _____
- 4 What range of resting heart rates would you expect to observe in a class of young, healthy adults (approximately)? _____ beats/min.
- 5 What correlations would you expect to observe between resting heart rate and gender, apparent fitness, or diet of your subjects? _____

Exercise 3: The ECG and Heart Sounds

Aim: To study the phasing of heart sounds to the ECG.

Procedure

- 1 Place the head of the stethoscope on the left side of the subject's chest and listen for the heart sounds. Move the stethoscope head to different positions until heart sounds are heard clearly. Heart sounds can also be heard by placing the stethoscope over the arteries in the neck.
- 2 Click **Record**. Hold the stethoscope head on the subject's chest with one hand and the event marker in the other. Press the event marker when you hear the "lub", or first heart sound, and release it when you hear the "dub", or second heart sound.
- 3 After recording for twenty seconds, click **Stop and Save**.

Data Analysis

- 1 Scroll through the recording and find a section of data with four to six exemplary ECG waveforms and consistent responses on the event marker channel, in succession.
- 2 Adjust the display time to show at least four complete ECG/heart sound cycles and transfer the data to the **Analysis** window (Figure HH-2-6, below).



Figure HH-2-6: ECG and event marker recordings displayed in the Analysis window. Lines and labels were added to the figure to indicate the locations where cursors should be placed to measure the time intervals between the R wave and the "lub" and the T wave and the "dub".

- 3 Use the mouse to click on and drag the cursors to specific points on the ECG recording to measure the following:
 - The **R-Lub Interval**, which is the time between the peak of an R wave and the onset of the event mark. The onset of the event mark indicates the occurrence of the first heart sound or "lub". Record the value for $T_2 - T_1$ of either channel. Measure this time interval for two additional ECG cycles.
Results (with units): _____
 - The **T-Dub Interval**, which is the time between the peak of a T wave and the offset of the event mark. The offset of the event mark indicates the occurrence of the second heart sound or "dub". Record the value for $T_2 - T_1$. Measure this time interval for two additional ECG cycles.
Results (with units): _____

4 Calculate the following values:

- The average R-Lub interval (with units): _____
- The average T-Dub interval (with units): _____

Questions

- 1 Why does the lub sound occur **shortly after** the peak of the R wave? _____

- 2 Is the time delay between the R wave and the lub sound always the same? _____ Explain why the time delay is or is not the same. _____

- 3 Why does the dub sound occur **shortly after** the peak of the T wave? _____

- 4 Is the time delay between the T wave and the dub sound always the same? _____ Explain why the time delay is or is not the same. _____

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