Experiment 31: Heart Sounds

Background

The cardiac cycle begins with the electrical activity of specialized myocardial cells in the sinoatrial (SA) node on the right atrium of the heart. The electrical activity spreads from the node across the muscle fibers of the atria, through another node and a set of fibers that go to the ventricles. The resulting sequential contraction and relaxation of the heart moves blood to the lungs and other organs. As blood moves between the atria and the ventricles, and the ventricles and the large blood vessels, the sounds of the valves between these parts of the circulatory system can be heard with a stethoscope. Electronic devices, like the heart sound monitor used in this experiment, can also be used to record and display the heart sounds as waveforms on a computer screen.

The electrical activity of the heart is recorded as an electrocardiogram (ECG in Figure 6-1 on page 1) with identifiable waves:

- The P wave is the summation of the action potentials from the muscle fibers in the atria. These action potentials, known collectively as the atrial depolarization, cause the contraction of the atria.
- The QRS complex, which results from the return of the atrial muscle fibers to their resting membrane potential, known as atrial repolarization, and the summation of the action potentials from all the muscle fibers in the ventricles. These ventricular action potentials, known collectively as the ventricular depolarization, cause the contraction of the ventricles.
- The T wave, which results from the return of the ventricular muscle fibers to their resting membrane potential, known as ventricular repolarization.

The mechanical activity of the heart chambers can be visualized by using ultrasound to create an echocardiogram. These tests are extremely effective at providing information about the size, volume, and thickness of the heart chambers, as well as the pumping function of the cardiac musculature and the structure and movement of the cardiac valves.The movement of blood through and out of the heart can also be visualized by using ultrasound to conduct a Doppler examination. The volume, velocity, and direction of blood moving through chambers can be measured with this technology.

The devices used to conduct echocardiograms and Doppler examinations are invaluable diagnostic tools. Before these electronic tools were available, the sounds created by the opening and closing of the valves between the chambers and vessels leaving the heart were used to diagnosis problems with the heart. the technique of listening to heart and vessel sounds is called auscultation. Practitioners use auscultation to detect subtle differences in heart sounds which may indicate irregularities in the heart and blood vessels. Finding these irregularities using auscultation leads to the use of ultrasonic tests to complete the diagnosis.

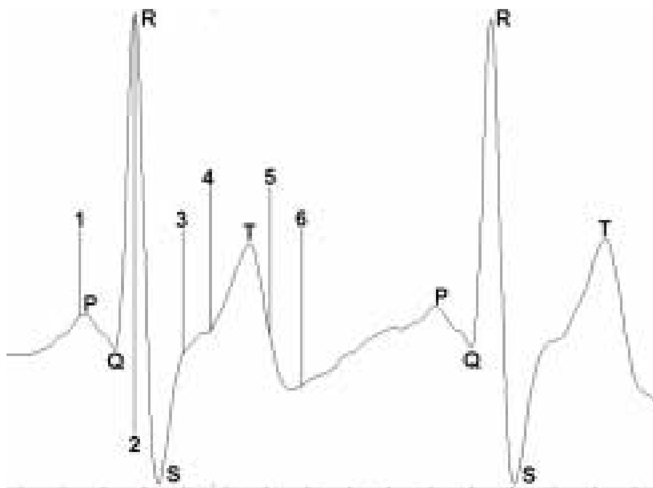

Figure 6-1: A typical ECG trace with labels identifying the P, QRS, and T waves and the points during the ECG cycle when mechanical events usually occur: 1, atrial contraction; 2, closing of the mitral and tricuspid values with the beginning of the ventricular contraction; 3, opening of the semilunar valves with the increase in ventricular pressure; 4, point of maximum ventricular and aortic pressure; 5, closing of the semilunar values as the ventricular pressure drops below the aortic pressure; 6, opening of the mitral and tricuspid valves as the ventricular pressure drops below the atrial pressure.

In this lab, you will record the heart sounds that occur during the cardiac cycle using a heart sound monitor placed on the four prescribed auscultation areas around the heart. The first heart sound (S1) occurs during the early phase of ventricular contraction and is produced by closing of the atrioventricular valves, which prevents blood flow back into the atria as the ventricle contracts. The second heart sound (S2) occurs when the ventricles relax and is produced by the closing of the semilunar valves, which prevents blood from flowing back into the ventricles from the large blood vessels. The ECG of the subject is recorded as the heart sounds are recorded so that you can visualize when heart sounds occur during the ECG cycle

Equipment Required

PC Computer

iWorx unit, and USB or serial cable

AAMI cable and three ECG leads

Alcohol swabs

HSM-300 heart sound monitor

Velcro chest belt or elastic bandage (Ace wrap)

Equipment Setup

1 Connect the iWorx unit to the computer (described in Chapter 1).

2 The volunteer should remove all jewelry from their wrists and ankles.

3 Use an alcohol swab to clean and scrub a region of each wrist, that has little or no hair. Let the area dry.

4 Remove the plastic disk from a disposable electrode and apply the electrode to the scrubbed area on one wrist. Repeat for the other wrist and the right ankle.

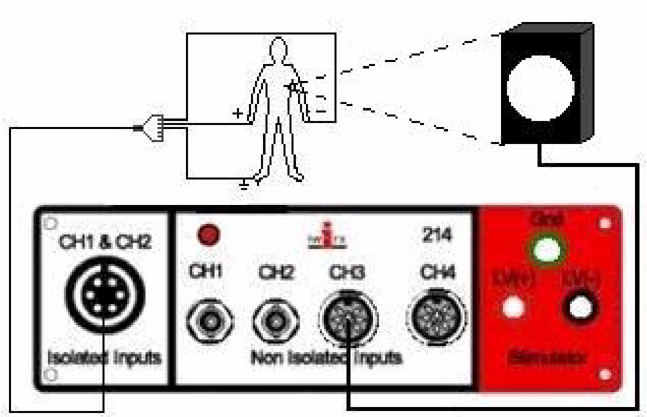

Figure 6-2: The equipment used to record the ECG and heart sounds from a volunteer.

5 Attach the AAMI connector on the end of the gray patient cable to the isolated Channel 1 & 2 inputs of the iWorx unit (Figure 6-2 on page 2).

6 Attach three color-coded electrode cables to the ground and Channel 1 inputs on the lead pedestal and snap the other ends onto the disposable electrodes, so that:

- the red "+1" lead is attached to the right wrist,
- the black "-1" lead is connected to the left wrist,
- the green "C" lead (the ground) is connected to right leg.

7 Plug the DIN connector of the HSM-300 heart sound monitor into Channel 3 (Figure 6-2 on page 2).

8 The volunteer should sit quietly with their hands in their lap.

Start the Software

1 Click the Windows **Start** menu, move the cursor to **Programs** and then to the **iWorx** folder and select **LabScribe**; or click on the LabScribe icon on the Desktop

2 When the program opens, select **Load Group** from the **Settings** menu.

3 When the dialog box appears, select **AddedLabs.iws**. Click **Load**.

4 Click on the **Settings** menu again and select the **Heart Sounds** settings file.

5 After a short time, LabScribe will appear on the computer screen as configured by the **Heart Sounds** settings.

Exercise 1: Heart Sounds from a Resting Subject

Aim: To record the heart sounds from different points around the chest of a resting subject.

Procedure

1 Make sure the ECG lead wires and electrodes are connected. Instruct the subject to move away from any electronic equipment and keep still when the ECG and the heart sounds are being recorded.

2 Firmly place the heart sound monitor on one of the four auscultation areas:

- **Aortic**, which is located in the second intercostal space at the right sternal margin, 1 on Figure 6-3 on page 2. At this location, the systolic murmurs of aortic stenosis and Increased aortic valve flow are the loudest.

- **Pulmonic**, which is located in the second intercostal space at the left sternal border, 2 on Figure 6-3 on page 2. At this location, the systolic murmur of pulmonic stenosis and the diastolic murmur of pulmonic regurgitation are the loudest.

- **Tricuspid**, which is located at the lower left sternal border, 3 on Figure 6-3 on page 2. At this location, the diastolic murmur of tricuspid stenosis is the loudest.

- **Mitral**, which is usually located in the fifth intercostal space, at the apex beat, 4 on Figure 6-3 on page 2. At this location, the systolic murmur of mitral regurgitation, and the diastolic murmurs of mitral stenosis and increased valvular flow, are the loudest.

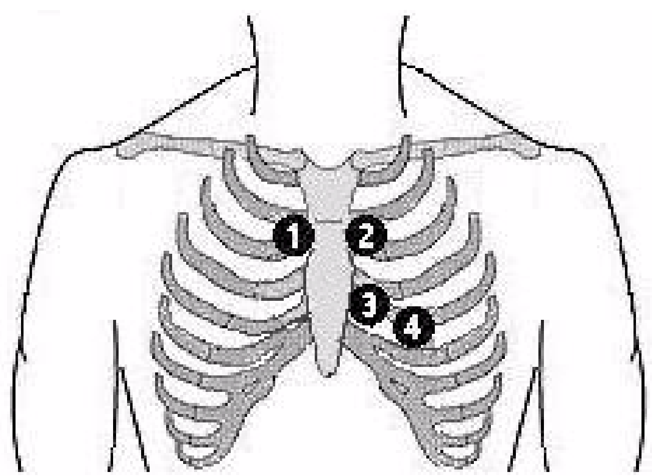

Figure 6-3: Positions of the auscultation areas on the chest: 1-Aortic, 2-Pulmonic, 3-Tricuspid, 4-Mitral.

3 Click **Start**, and then click **AutoScale** in the title area of the **ECG, HS Integral** and **Heart Sounds** channels. Observe the rhythmic ECG and heart sounds signals. If the ECG and heart sounds signals are sizable and relatively noise-free (Figure 6-4 on page 3), proceed to Step 6. If the recorded signals are noisy, proceed to Steps 4 and 5.

4 If the ECG recording is noisy, use the digital **Filter** in the **Right-click** menu of the **Main** window to create narrower band pass filter. Moving the recording electrodes to the skin immediately below each clavicle will also reduce noise.

5 If the heart sound recording is noisy, press the heart sound monitor against the chest more firmly or hold it in place with an elastic bandage (Ace wrap) or belt. Also, have the subject hold his or her breath during the recording.

6 When you have a suitable trace, type the name of the subject and the auscultation area used for the recording in the comment line to the right of the **Mark** button. Press the **Enter** key on the keyboard to attach the comment to the data. Record at least 10 seconds of noise-free ECG.

7 Click **Stop** to halt recording.

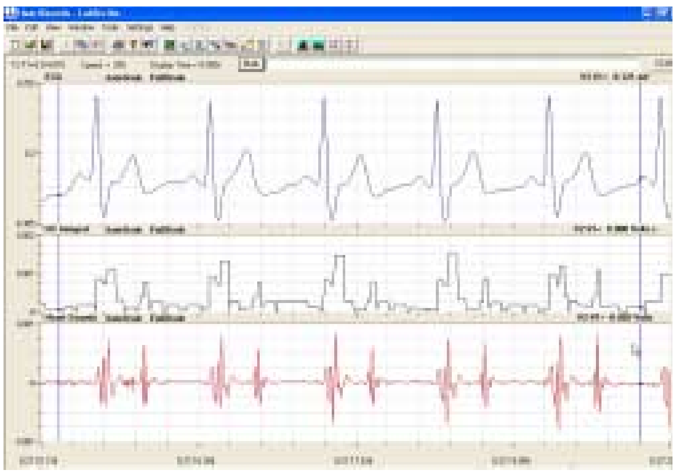

Figure 6-4: Recording of ECG, heart sounds integral, and heart sounds displayed in the Main window.

8 Repeat Steps 2 through 7 for the other three auscultation areas.

9 Select **Save As** in the **File** menu, type a name for the file. Choose a destination on the computer in which to save the file(e.g. the **iWorx** or class folder). Click the **Save** button to save the file (as an ***.iwd** file).

Data Analysis

1 Click the **2-Cursor** icon (Figure 6-5 on page 3) so that two blue vertical lines appear over the recording window.

Figure 6-5: The LabScribe toolbar.

2 Drag the cursors left and right so that five complete cardiac sound cycles taken from the first auscultation area, while the subject was resting are located between the two blue lines.

3 Click the **Analysis** icon (Figure 6-5 on page 3) to open the **Analysis** window.

4 Select **HS Integral** (CH 2) from the **Value from Ch** menu, and set the **Precision** = **5**. Display all three channels. Select **Title** and **T2-T1** from the **General Table Functions** and **Area** from the **Periodic Table Functions**.

5 Move the cursors to the first heart sound (S1) in the first of the five selected cardiac sound cycles. Place one cursor at the beginning of the first S1sound wave and the second cursor at the end of the same S1 sound wave. The values for the **Area** and the duration (**T2-T1**) of the **HS Integral** of this S1 are displayed in the table in the title area of this window (Figure 6-6 on page 3).

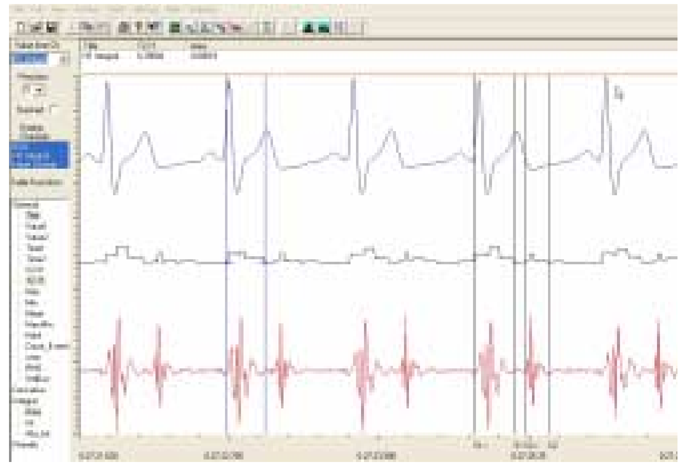

Figure 6-6: The ECG, heart sounds integral, and heart sounds displayed in the Analysis window. The cursors are placed at the beginning and the end of the second S1 heart sound in the window and the margins of the S1 and S2 sounds of the fourth ECG cycle are marked.

6 These values can be entered into the **Journal** by either typing the titles and values directly, or by using the **right-click** menu. When using the functions in the **right-click** menu of the **Analysis** window, place the cursors to take measurements, then, select **Add Title to Journal** or **Add Data to Journal** to add the values to the **Journal.**

7 Repeat Steps 5 and 6 for the S1 heart sounds in the four other cardiac cycles displayed on the window.

8 Repeat Steps 5 and 6 for the S2 heart sounds in the five cardiac cycles from the first auscultation area.

9 Repeat Steps 5 and 6 for the S1 and S2 sounds from five cardiac cycles recorded from each of the three other auscultation areas.

10 Find the average area and average duration of the **HS Integrals** for the S1 and S2 sounds taken from the four auscultation areas described earlier. Report the averages for these values in the appropriate section of Table 6-1 on page 5.

11 Calculate the ratio of the average area to the average duration of the **HS integrals** for the S1 and S2 heart sounds from each auscultation area. This ratio (**Area/Duration**) will yield a value that is the relative amplitude of each heart sound from each auscultation area.

Questions

1 From the data collected while the subject was resting, compare the relative amplitude (**Area/Duration** in Table 6-1 on page 5) of the S1 heart sound from the **Aortic** auscultation area to the relative amplitude of the S2 heart sound from the same auscultation area? Which sound, S1 or S2, is

louder at this auscultation area?

2 From the other data collected while the subject was resting, compare the relative amplitude (**Area/Duration** in Table 6-1 on page 5) of the S1 heart sound to the relative amplitude of the S2 heart sound for each of the other three auscultation areas? Which sound, S1 or S2, is louder at the **Pulmonic** area? At the **Tricuspid** area? At the **Mitral** area?

Note: *Compare the relative amplitude of S1 to the relative amplitude of S2 from the same auscultation area. Do not compare the relative amplitude of S1 from one auscultation area to the relative amplitude of S1 or S2 from another auscultation area. Comparisons between heart sounds from different auscultation areas are invalid because: the force holding the heart sound monitor to the chest probably varies between recordings made from different auscultation areas; and, the thickness and density of the chest wall varies between auscultation areas.*

3 For each auscultation area, which heart sound, S1 or S2, has the higher relative amplitude? Which auscultation area shows the greatest difference between the relative amplitudes of S1 and S2?

4 The S1 heart sound is associated with ventricular contraction and the S2 heart sound is associated with ventricular relaxation. Predict which auscultation areas should have higher relative amplitudes of S1? Of S2? Which auscultation areas actually have higher amplitudes of S1 and S2?

5 Compare the recording of the ECG and heart sounds taken from the **Mitral** auscultation area of your subject to labeled ECG in Figure 6-1 on page 1. Which valves open or close during a typical S1 recorded from your subject? Which valves open and close during a typical S2 recorded from your subject?

Exercise 2: Heart Sounds after Exercise

Aim: To record the heart sounds from auscultation areas on the same subject used in Exercise 1 as the subject is recovering from exercise.

Procedure

1 Remove the ECG snap leads from the subject's electrodes and the heart sound monitor from the subject's chest.

2 Prepare to reattach the ECG lead wires and heart sound monitor to the subject as soon as the subject finishes exercising.

3 Have the subject exercise by running in place, climbing stairs, or pedaling a bicycle. After 2 minutes of exercise, have the subject sit down. Reattach the ECG lead wires to the electrodes and place the heart sound monitor on the subject's aortic auscultation area as quickly as possible.

4 Click **Start**, and then click **AutoScale** in the title area of the **ECG, HS Integral** and **Heart Sounds** channels. Observe the rhythmic ECG and heart sounds signals. If the ECG and heart sounds signals are sizable and relatively noise-free (Figure 6-4 on page 3), proceed to Step 6. If the recorded signals are noisy, proceed to Steps 5 and 6.

5 If the ECG recording is noisy, use the digital **Filter** in the **Right-click** menu of the **Main** window to create narrower band pass filter. Moving the recording electrodes to the skin immediately below each clavicle will also reduce noise.

6 If the heart sound recording is noisy, press the heart sound monitor against the chest more firmly or hold it in place with an elastic bandage (Ace wrap) or a belt. Also, have the subject hold his or her breath during the recording.

7 When you have a suitable trace, type the name of the subject and the auscultation area used for the recording in the comment line to the right of the **Mark** button. Press the **Enter** key on the keyboard to attach the comment to the data. Record at least 10 seconds of noise-free ECG.

8 Click **Stop** to halt recording.

9 Repeat Steps 4 through 8 for the other three auscultation areas.

10 Select **Save As** in the **File** menu, type a name for the file. Choose a destination on the computer in which to save the file(e.g. the **iWorx** or class folder). Click the **Save** button to save the file (as an ***.iwd** file).

Data Analysis

1 Click the **2-Cursor** icon (Figure 6-5 on page 3) so that two blue vertical lines appear over the recording window.

2 Drag the cursors left and right so that five complete cardiac sound cycles taken from the first auscultation area, during the subject's recovery from exercise, are located between the two blue lines.

3 Click the **Analysis** icon (Figure 6-5 on page 3) to open the **Analysis** window.

4 Select **HS Integral** (CH 2) from the **Value from Ch** menu, and set the **Precision** = **5**. Select **HS Integral** and **Heart Sounds** in the **Display Channels** box on the left side of the **Analysis** window. Select **Title** and **T2-T1** from the **General Table Functions** and **Area** from the **Periodic Table Functions**.

5 Move the cursors to the first heart sound (S1) in the first of the five selected cardiac sound cycles. Place one cursor at the beginning of the first S1sound wave and the second cursor at the end of the same S1 sound wave. The values for the **Area** and the duration (**T2-T1**) of the **HS Integral** of this S1 are displayed in the table in the title area of this window (Figure 6-6 on page 3).

6 These values can be entered into the **Journal** by either typing the titles and values directly, or by using the **right-click** menu. When using the functions in the **right-click** menu of the **Analysis** window, place the cursors to take measurements, then, select **Add Title to Journal** or **Add Data to Journal** to add the values to the **Journal.**

7 Repeat Steps 5 and 6 for the S1 heart sounds in the four other cardiac cycles displayed on the window.

8 Repeat Steps 5 and 6 for the S2 heart sounds in the five cardiac cycles taken from the first auscultation area while the subject was recovering from exercise.

9 Repeat Steps 5 and 6 for the S1 and S2 sounds from five cardiac cycles taken from each of the three other auscultation areas while the subject was recovering from exercise.

10 Find the average area and average duration of the **HS Integrals** for the S1 and S2 sounds taken from the four auscultation areas while the subject was recovering from exercise. Report the averages for these values from the exercise recovery period in the appropriate section of Table 6-1 on page 5.

11 Calculate the ratio of the average area to the average duration of the **HS integrals** for the S1 and S2 heart sounds from each auscultation area while the subject was recovering from exercise. This ratio (**Area/Duration**) will yield a value that is the relative amplitude of each heart sound from each auscultation area.

Questions

1 From the data collected while the subject was recovering from exercise, compare the relative amplitude (**Area/ Duration** in Table 6-1 on page 5) of the S1 heart sound from the **Aortic** auscultation area to the relative amplitude of the S2 heart sound from the same auscultation area? Which heart sound, S1 or S2, has the higher relative amplitude at the **Aortic** area?

2 From the other data collected while the subject was recovering from exercise, compare the relative amplitude (**Area/ Duration** in Table 6-1 on page 5) of the S1 heart sound to the relative amplitude of the S2 heart sound for each of the other three auscultation areas? Which sound, S1 or S2, has the higher relative amplitude at the **Pulmonic** area? At the **Tricuspid** area? At the **Mitral** area?

Note: *Compare the relative amplitude of S1 to the relative amplitude of S2 from the same auscultation area. Do not compare the relative amplitude of S1 from one auscultation area to the relative amplitude of S1 or S2 from another auscultation area. Comparisons between heart sounds from different auscultation areas are invalid because: the force holding the heart sound monitor to the chest probably varies between recordings made from different auscultation areas; and, the thickness and density of the chest wall varies between auscultation areas.*

3 For each auscultation area, is the heart sound that has the higher relative amplitude while the subject was recovering from exercise the same as the heart sound that had the higher relative amplitude while the subject was resting?

Table 6-1: Areas and Durations (Dur) of the S1 and S2 Heart Sounds

	Average Values While Resting						Average Values After Exercise					
	S1			S2			S1			S2		
Auscultation Area	Area (V.s)	Dur(s)	Area / Dur	Area (V.s)	Dur(s)	Area / Dur	Area (V.s)	Dur(s)	Area / Dur	Area (V.s)	Dur(s)	Area / Dur
Aortic												
Pulmonic												
Tricuspid												
Mitral												

Exercise 3: Heart Sounds from Other Subjects at Rest

Aim: To record the heart sounds from auscultation areas around the chest of other subjects.

Procedure

Follow the ***Procedure*** used for Exercise 1 with a new subject.

Data Analysis

Perform the same ***Data Analysis*** conducted in Exercise 1 on the data collected in this exercise.

Questions

1 Answer the same questions listed for Exercise 1 for the data collected from the new subject.

2 Are there any significant differences between the heart sounds from different subjects that are resting?

Exercise 4: Heart Sounds from Other Subjects after Exercise

Aim: To record the heart sounds from auscultation areas on the same subject used in Exercise 3 as the subject is recovering from exercise.

Procedure

Follow the ***Procedure*** used for Exercise 2 with the same subject used in Exercise 3.

Data Analysis

Perform the same ***Data Analysis*** conducted in Exercise 2 on the data collected in this exercise.

Questions

1 Answer the same questions listed for Exercise 2 for the data collected from the new subject.

2 Are there any significant differences between the heart sounds from different subjects that are recovering from exercise?