BE 3600 BIOMEDICAL INSTRUMENTATION (LAB) -

Experiment 5: Pressure and Sound Measurement Systems

OBJECTIVE:

Learn the sources of heart sounds and understand methods to record and analyze these sounds in relation to ECG.

BACKGROUND ON HEART SOUNDS:

Physicians listen to heart sounds for the purpose of diagnosing various cardiac malfunctions. Within a cardiac cycle, there are four sounds produced by the mechanical activity of the heart.

S_1: First heart sound is initiated by the onset of ventricular systole. It is the longest and loudest of the four sounds. S_1 is heard best over the apical region of the heart. S_1 is produced by the oscillation of blood in the ventricular chambers and vibration of the ventricular free wall. At the onset of systole, ventricular pressure begins to increase and forces the blood within the ventricles toward the atria through the mitral and tricuspid valves. As these one way valves close, blood and the ventricular wall vibrates producing the S_1 sound. Therefore, S_1 sound is expected soon after the onset of the ventricular contraction, QRS wave of the ECG. Heart now is in the iso-volumetric contraction phase of the cardiac cycle.

S_2: The second heart sound is generated the end of the ejection of the blood from the ventricles by the closure of the semilunar valves, i.e. aortic and pulmonic valves. At this point, blood from the ventricle is pumped into the arteries, arterial pressure exceeded the ventricular pressure, hence the one way valves are closing as the pressure is reversed. These sounds have higher frequency components and the aortic valve sound is louder than the pulmonic valve sound.

S_3: This heart sound is heard in young children and patients with left ventricular failure and believed to be resulted by the deceleration of blood entering the ventricle. In enlarged hearts, ventricular walls are stretched beyond normal ranges and are under tension allowing vibrations.

S_4: Is the weakest on of all the heart sounds and heard occasionally. It is not related to a pathological condition and believed to be due to the oscillation of blood in the atria and atrial walls. It occurs immediately after the P-wave in the ECG.

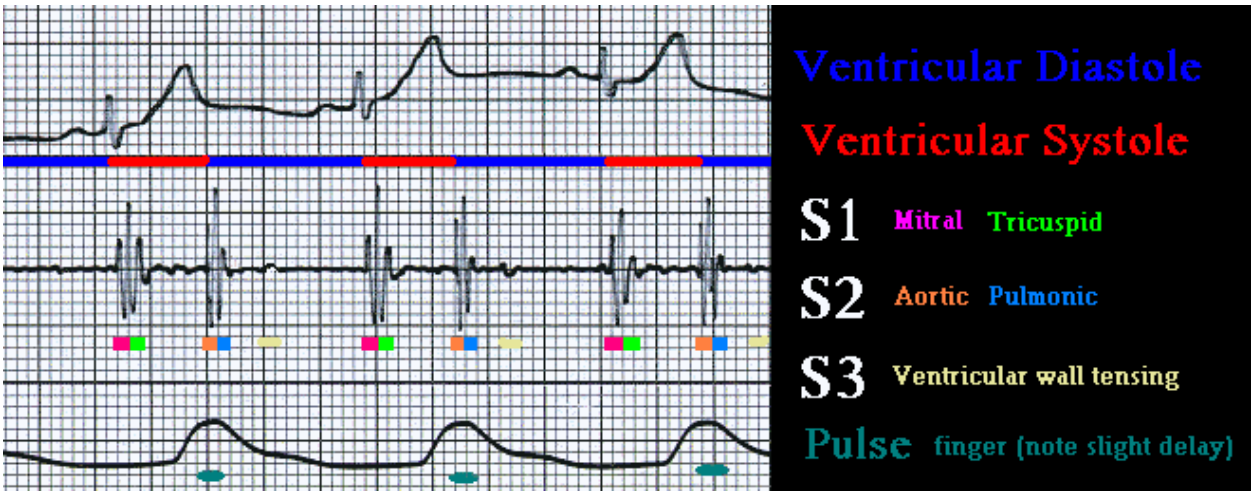

Figure 1. Timing of the heart sounds in relationship to the electrical events detected in ECG waveforms (from: http://www.monroecc.edu/depts/pstc/parashs.htm)

BACKGROUND ON AUSCULTATION

Auscultation refers to the diagnostic monitoring of the sounds produced by internal organs, as in the case of heart sounds. Heart sounds are usually listened with a stethoscope. Rules for correct use of the stethoscope is as follows:

1. Chest piece should be placed directly against the subject's skin.
2. The chest piece should be applied with enough pressure to leave a slight depression when removed. However, excessive pressure over blood vessels may obstruct flow, causing loss of sound.
3. If possible, try to make a air tight contact, sealed all around the perimeter of the chest piece.
4. The finger holding the chest piece should remain straight and still. It is best to use the index finger to press on the stethoscope while holding the chest piece in place with thumb and middle fingers. Tubing should be in the palm of the hand holding the stethoscope and be extending towards the wrist.
5. Stretching of the tubing should be avoided.

Locations to detect various heart sounds on the chest are shown on Figure 2 below. You might also want to visit the following URL to hear some of these heart sound before you come to the lab to familiarize yourself with the heart sounds:
http://www.monroecc.edu/depts/pstc/parashs.htm

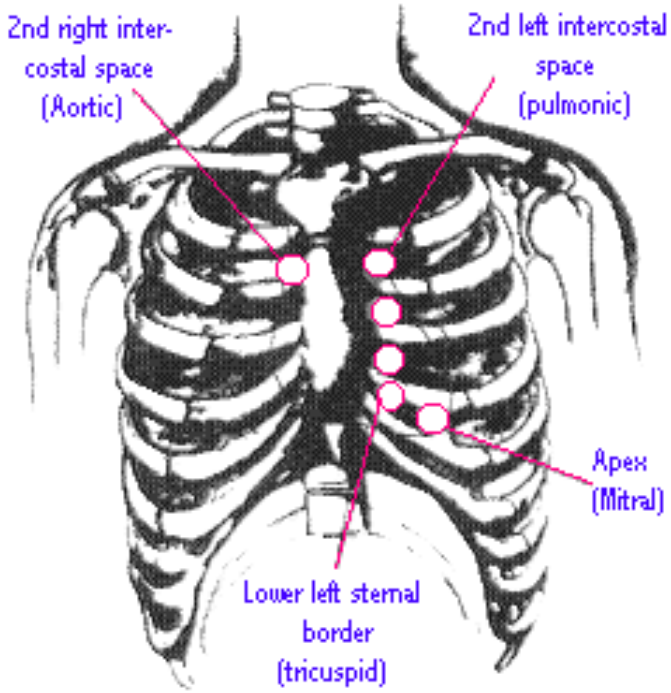

Figure 2. Auscultation Locations on the chest
(from http://members.ams.chello.nl/j.scholten9/)

BACKGROUND ON PHONOCARDIOGRAPHY:

In order to make permanent records of the heart sounds, stethoscopes with built in microphones can be used. These devices incorporate a microphone in the stethoscope and produce an electronic signal representing the heart sounds.

EXPERIMENT:

1. Connect ECG electrodes in Lead 2 configuration.
2. Connect the stethoscope to the stethoscope amplifier.
3. Connect both the stethoscope and ECG amplifiers to the oscilloscope. Before working with the stethoscope, assure that a reliable ECG signal is available.
4. Place the stethoscope over the chest, toward the center of the sternum. Move it if necessary until you identify a location where you can hear both S_1 and S_2 sounds.
5. Make a recording of the screen, containing at least one, preferably two cardiac cycles.
6. Increase your heart activity.
7. Repeat step 5.
8. Transfer your data to a floppy disk.

REPORT:

a. Which ones of the four heart sounds are audible in healthy individuals?

b. Show the timing of the all four of the heart sounds and P and QRS complexes of ECG using a hypothetical diagram. Clearly identify the sequence of occurrence of each event within the cardiac cycle.

c. What part of the cardiac cycle is defined by the S_2-S_1 timing, i.e. the time from S_1 to S_2?

d. Plot the data you recorded. Label the features of ECG and auscultatory signals.

e. Measure the S_1 - S_2 timing for both cases as well as the heart rate. Does S_1 - S_2 duration relate to heart rate?

f. Measure the amplitude and the frequency of S_1 and S_2 sounds from your recordings. Comment on the comparative values of the amplitudes and frequencies. Are they what you expect from the background section? If not, formulate a hypothesis to explain the discrepancy.