IMPEDANCE CARDIOGRAPHY

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Client: Professor John Webster

Objective Statement

The purpose of this project is to design and implement a reliable and spatially specific impedance cardiograph system. Ideally, such a system should offer greater accuracy than comparable methods.

Problem

Impedance cardiography is a non-invasive procedure used to assess the state of an individual's circulation. With the information attained from an impedance test, vital stats can be deduced, of which includes the volume of blood flow through the aorta, or cardiac output. In the neck-abdomen method of testing, four dual electrodes are placed on the neck and abdomen. However, it is suspected that placing the electrodes with a large separation distance results in an inaccurate and weak output signal. As a result, a proposed solution to move the electrodes directly over the heart aims to improve upon this non-invasive method of cardiography.

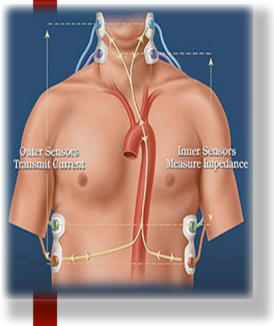

Figure 1

Client Requirements

- Electrodes must be placed over the heart
- System must reduce noise as much as possible
- Optimal position for measurement must be determined
- Testing apparatus should be reusable

Final Design

Amplifier

Our amplifier (*figure 2*) is crucial to amplify the impedance signal discovered from our carrying wave. We incorporated a high pass filter at the beginning of our amplifier in order to attempt to eliminate the ECG. The amplifier set up we use is the traditional ECG amp presented in Professor Webster's BME 310 course. After the amp we rectify the signal and pass it through a low pass filter in order to eliminate our 150 KHz carrying wave. The result is a pressure wave as seen in figure 3.

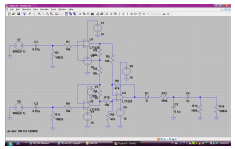

Figure 2

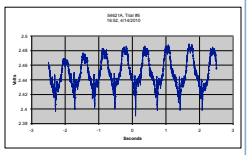

Figure 3

Improved Electrode Matrix

We designed an electrode matrix in order to be more efficient with our testing (*see figure 4*). This new electrode matrix allows us to test the best orientation of electrodes for the highest impedance signal. The Tyvek® is just as durable as our initial silicone, but this design provides a simple change of electrodes and easier testing orientation. This improvement was a crucial turning point for our project

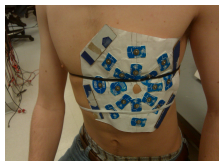

Figure 4

Demodulator

The demodulator (shown in figure 5) is designed by our international colleagues. This demodulator is designed to eliminate the 150kHz carrier signal sent through the aorta of subjects. The demodulator will extract the signal envelop, which possibly indicates cardiac output. This is similar to our filter design and is currently undergoing testing in China.

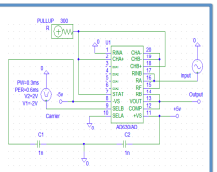

Figure 5

Testing and Results

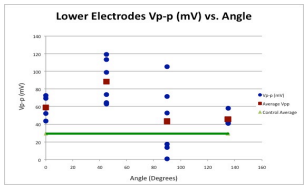

Figure 6

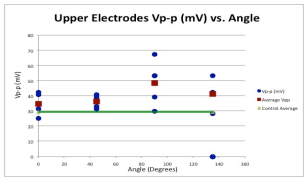

Figure 7

In order to determine whether or not the method provides a viable alternative to current impedance methods, measurements were first taken with the neck-abdomen method. This test provides a basis of comparison for our suggested method.

We then tested electrodes at the angles of 0, 45, 90, and 135 degrees directly over the heart to determine the optimal position at which to take impedance readings. We tested both the top and bottom four electrodes at each angle five times.

Our initial results (*figures 6 & 7*) indicate that the lower four electrodes placed at 45 degrees gives us the strongest peak-to-peak voltage signal so far. The signal is three times stronger compared to the neck-abnormal control data.

Future Work

- **Perform more extensive human testing so as to include biovariation.**
- **Verify 45 degree angle is optimum by taking more measurements**
- **Compare thermodilution method used in surgery to our new method**
- **Develop model to use for female patients that is equally as effective**
- **Acquire demodulator results**

References

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