Atrial fibrillation (AF) is defined as a varying heart rate which can cause reduced blood flow to the body. It is the most common arrhythmia and it occurs when the electrical signals of the heart’s atria are disorganized. AF affects close to 3 million people in the US and around 6 million people in Europe. AF can cause many life-threatening problems, one of which is stroke.

This is a preliminary study that explores lead placements for atrial fibrillation quantification. The objective of this study was to locate the best lead placement to maximize AF detection using the least number of leads.

Data was collected at the Rochester Cardiopulmonary Group from two patients who were experiencing paroxysmal AF. Clinical lead placement is needed to collect and analyze using our developed lead setup.

Combinations in the same direction of the P wave dipole produced higher entropies and higher dominant frequencies.

Combination V1L-VSR produced high entropies in both patients.

V2L-VSR and V3L-VSR combinations produced one of the highest dominant frequencies.

This preliminary study suggests that a reduced lead set up from a left-right combination could allow for an ambulatory AF detection device while preserving the AF detection accuracy.

In order to generalize our observations in this study, more AF data needs to be collected and analyzed using our developed lead setup.

**Background**

**Atrial Fibrillation** (AF) is defined as a varying heart rate which can cause reduced blood flow to the body. It is the most common arrhythmia and it occurs when the electrical signals of the heart’s atria are disorganized. AF affects close to 3 million people in the US and around 6 million people in Europe. AF can cause many life-threatening problems, one of which is stroke.

**Objectives**

This is a preliminary study that explores lead placements for atrial fibrillation quantification. The objective of this study was to locate the best lead placement to maximize AF detection using the least number of leads.

**Experiment Setup**

Data was collected at the Rochester Cardiopulmonary Group from two patients who were experiencing paroxysmal AF. Clinical lead placement is displayed in Figure 3 and the setup used in this experiment is shown in Figure 4. Data was collected using two GE 12-channel Holter Recording Devices for an hour. The sampling frequency of the devices was 1024Hz. The recordings were divided into sections which contained 100,000 samples (~98 secs) each.

**AF Detection Methods**

**Entropy**

Entropy is a measure of the uncertainty of a random variable. It is used here to quantify the atrial activity of AF patients. The entropy of each signal section was calculated using the following equation:

\[
H(X) = - \sum P(X_i) \log_2 P(X_i)
\]

**Spectral Analysis**

The dominant frequency is known as the frequency with the highest peak. This is applied to the atrial activity (between 4Hz and 10Hz) of the FFT (Fast Fourier Transform) of each of the signal sections. The dominant frequency was analyzed for each section.

**Results**

**Corrections**

1. **Time Delay**
   - Both Holter Recording Devices were started manually, which introduced a time delay in the recording. Lead I was used to align the R-peaks of the Left Holter and the Right Holter.
   - Lead I was used to create a QRS template signal and bottom figure demonstrates the subtraction of the two.
   - Middle figure displays the QRS template signal and bottom figure displays irregular F waves during AF.

2. **Bandpass Filter**
   - Frequency cutoffs at 0.5Hz and 50Hz. Low-pass filter was used to remove noise while the high-pass filter removes baseline wander.

3. **QRS Complex Cancellation**
   - P-peaks of the ECG signals were used to create a template of the QRS complexes. The template was then subtracted from each QRS occurrence. This process is displayed in Figure 6.

4. **Lead Combination**
   - V1 and V2 in Figure 4 are the same location as the clinical placement of V1 and V2. Also, the leads in Figure 4 are unipolar leads (bipolar with respect to Einthoven’s Triangle) and are combined to create 66 bipolar connections. The leads are subtracted from one another starting with: V1B-V2B and ending with V5R-V6R.

\[
R_{ij} = R_j - R_i \\
i, j \in \{B_1, B_2, ..., B_6 \} \quad R_1, ..., R_6
\]

**Conclusion**

- Combinations in the same direction of the P-wave dipole produced higher entropies and higher dominant frequencies.
- Combination V1L-VSR produced high entropies in both patients.
- V2L-VSR and V3L-VSR combinations produced one of the highest dominant frequencies.
- This preliminary study suggests that a reduced lead set up from a left-right combination could allow for an ambulatory AF detection device while preserving the AF detection accuracy.
- In order to generalize our observations in this study, more AF data needs to be collected and analyzed using our developed lead setup.