Preliminary Human-Subject Results of ACT5 EIT System

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Abstract: Initial human-subject results from the ACT5 EIT system are presented. The results include images showing pulsatile perfusion at a sequence of time snapshots in the cardiac cycle in addition to electrocardiogram (ECG) measurements collected simultaneously from multiple electrodes.

1 Introduction

The ACT5 EIT is a multiple-source applied-current EIT system that has recently been developed and is in use in the hospital environment for imaging the lung performance of cystic fibrosis patients. The deployed ACT5 system has 32 electrodes, with each electrode equipped with a current source and a voltmeter. This makes it possible to use a fewer number of electrodes in cases where attaching all 32 electrodes to the patient is not possible. Maximum amplitude of the applied current from one electrode is $350\,\mu\text{A}$ and the frequency of the applied currents is set at $99.6\,\text{kHz}$. ACT5 collects data at a rate of $27\,\text{frames}/\text{sec}$ and the frame rate can be doubled to $54\,\text{frames}/\text{sec}$ when 16 or fewer electrodes are used. Each electrode in the ACT5 system collects ECG data simultaneous with the EIT data with a sampling frequency of $864\,\text{Hz}$ [1]. Recording ECG signals from all electrodes in parallel with EIT imaging provides the opportunity to use ACT5 data to solve the inverse ECG problem.

2 Methods & Results

Data was collected from a healthy adult subject. The electrode configuration is set as two rings of 16 electrodes around the thorax region to provide a 3D image as shown in Fig. 1. Data was collected with the subject in the supine position during breath holding. Images were reconstructed using the ToDLeR algorithm [2].

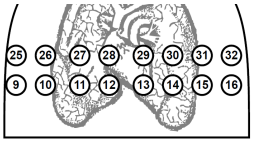

Figure 1: Electrode placement on subject (front view).

The reconstructed images of four stages in the cardiac cycle are shown in Fig. 2, which are displayed in DICOM orientation. The stages include the beginning of the P wave (top left), end of diastole (top right), beginning of T wave (bottom left), and end of systole (bottom right).

The ECG measurements from eight electrodes are shown in Fig. 3. The ECG measurements are referenced to common voltage and filtered for $60\,\text{kHz}$ and harmonics of the frame rate frequency.

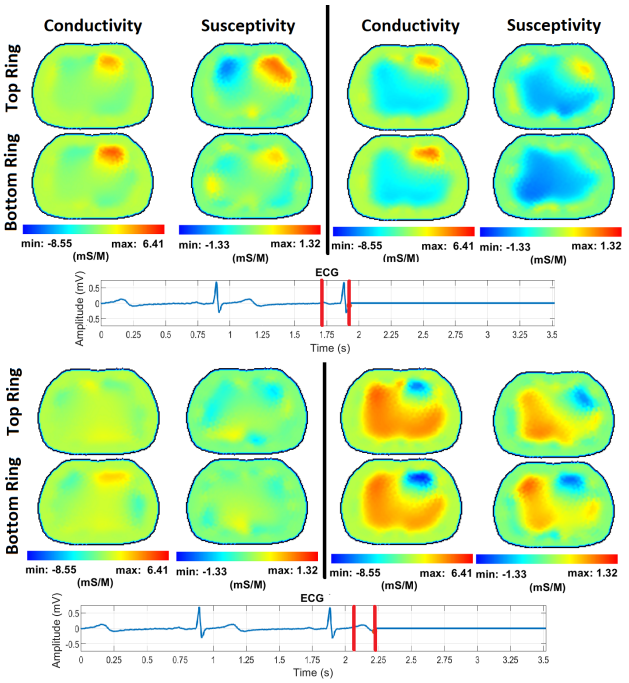

Figure 2: Reconstruction of four stages in the cardiac cycle.

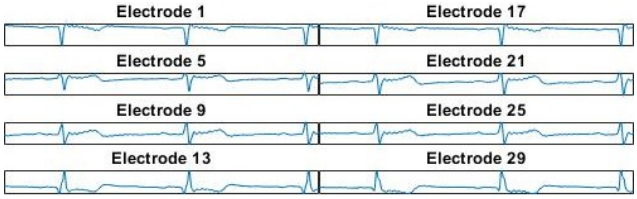

Figure 3: ECG signal recordings on 8 select electrodes.

3 Conclusions

This demonstrates the ability of ACT5 to simultaneously measure EIT data and ECG data from each of its 32 electrodes while making impedance images during the cardiac cycle. These impedance images show the 4 distinct phases of conductivity distributed withing the chest in synchrony with the 4 moments of the cardiac cycle indicated on the ECGs.

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Human data collection is in accordance with the amended Declaration of Helsinki–Ethical Principles for Medical Research Involving Human Subjects under the approval of the Colorado State University Institutional Review Board (approval number 2943) with informed written consent.

References

[1] A Abdelwahab, O Rajabi Shishvan, GJ Saulnier *Conf 14th ICBEM & 18th ICBEI & 22nd EIT*, p.208–211, Seoul, South Korea, Jun 2022

[2] RS Blue, D Isaacson, JC Newell *Physiol Meas*, 21:15–26, 2000