Multi-channel EIT for layer-based hydration monitoring

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Abstract: Accurate monitoring of hydration level in patients remains a major challenge for hemodialysis therapy. Using a prototype EIT system with simultaneous multi-channel current excitation, we demonstrated the capability to detect a difference of 35ml daily fluid change in human subjects who wear compression sock only on one leg. The prototype system has the potential to be used in clinical settings with hydration monitoring needs.

1 Introduction

Fluid balance is of great importance for hemodialysis therapy. Poor assessment of hydration status during hemodialysis can lead to under- or over- hydration in patients with consequences of increased morbidity and mortality. In current practice, fluid management is largely based on clinical assessments to estimate dry weight. Since hemodialysis patients usually have co-morbidities that can make the signs of fluidic status ambiguous, dry weight estimation remains a major challenge for hemodialysis therapy[1].

EIT has emerged as a non-invasive method for hydration monitoring. Conventional EIT hydration monitoring systems employ single-channel current excitation to extract hydration information from bulk tissue. In the present study, a prototype GE GENESIS EIT system with multi-channel current excitation was used to enable layer-based hydration monitoring in human legs with minimal interference from skin artifacts.

2 Methods

2.1 Experiment protocols

Proof-of-concept experiment in chicken breast

We injected conductive saline mixed with food dye into different depths of a chicken breast positioned on top of a linear eight-electrode array, impedance change was recorded during the injection process.

Healthy human subject experiment protocol

Healthy subjects reported to the lab at the beginning of their workday. We placed 8-electrode linear arrays on the outside calf of each leg. Multiple current patterns were applied to each leg and impedance measurements were recorded. Volume of each leg was recorded by weighing the amount of water displaced from an edema gauge. The subjects were asked to wear one compression sock on one leg and return to their normal daily work. At the end of the workday, the subjects returned to the lab where the compression sock was removed and measurements of impedance and volume on both calves were repeated.

2.2 Reconstruction algorithms

A linear reconstruction algorithm is used to extract impedance differences due to fluid changes as previously described.[2,3]

3 Results and conclusions

3.1 Detection of layer-based hydration change in chicken breasts

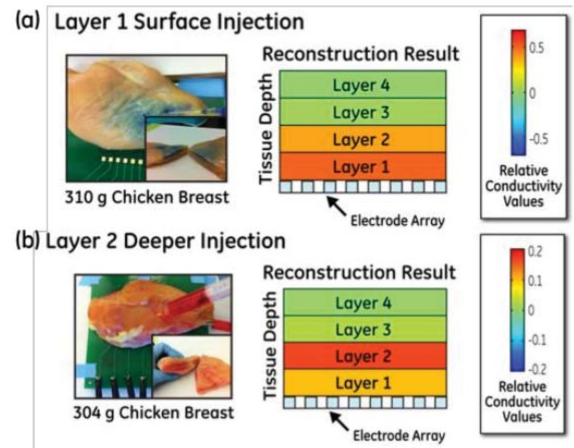

Figure 1: The GE GENESIS EIT system can detect hydration change at different tissue layers in a chicken breast. (a) Surface tissue layer injection; (b) deeper tissue layer injection.

3.2 Detection of layer-based hydration change in human subjects

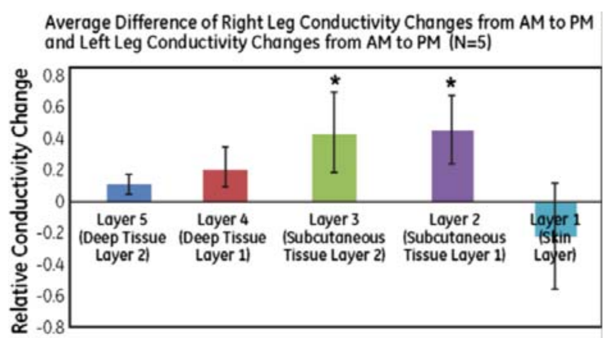

Figure 2: Multi-channel EIT can detect layer-based hydration difference between two legs induced by compression sock

3.3 Conclusion

The multi-channel EIT prototype system offers layer-based hydration monitoring in human subjects.

References

[1] Lindley, Elizabeth, Lynne Aspinall, Claire Gardiner and Elizabeth Garthwaite. 2011. Management of Fluid Status in Haemodialysis Patients: The Roles of Technology and Dietary Advice, Technical Problems in Patients on Hemodialysis.

[2] Mueller JL, D Isaacson D, Newell JC, A reconstruction Algorithm for Electrical Impedance Tomography Data Collected on Rectangular Electrode Array" IEEE Trans. Biomed. Engr., 46(11): 1379-1386, 1999

[3] Kao TJ, Isaacson D , Newell JC, and Saulnier GJ, A 3D reconstruction algorithm for EIT using a handheld probe for breast cancer detection, Physiol Meas. 2006 May; 27(5): S1–11

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