DeltaP: Non-Invasive Urine Output Monitoring via Bioimpedance

A Wearable System for Early Detection of Acute Kidney Injury

Design Team 04: Elliott Leow · Jiyoon Beris · Megh Tank · Ariel Jang · Jonathan Zhang · Avyay Balaji · Isabelle Lee · Anika Garg
Faculty Mentor: Michelle Zwernemann | Clinical Mentor: Nitya Srialluri, MD, Matthew Gross, MD — Johns Hopkins University School of Medicine

JOHNS HOPKINS BIOMEDICAL ENGINEERING

"Smarter Monitoring Starts at the Surface"

deltaP

PROJECT OVERVIEW

Acute kidney injury (AKI) is a condition that causes 1.7 million deaths globally each year. Urine output (UO) is the earliest AKI biomarker, but it is currently measured via Foley catheterization, which causes ~1 million CAUTIs annually in the U.S., while noninvasive detection alternatives remain inaccurate. We aim to meet the need for a reliable noninvasive UO-monitoring system by designing a wearable bioimpedance device that uses surface abdominal electrodes to continuously estimate UO in real time, targeting ±0.075 mL/kg/hr accuracy for KDIGO-compliant AKI staging without catheterization.

Acute kidney injury (AKI) is a sudden decline in kidney function. Urine Output (UO) is one of the earliest biomarkers for AKI.

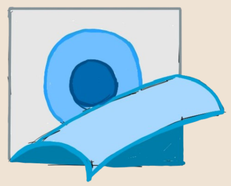
13.3M	1 in 5	68%	$10B
AKI cases/year globally	hospitalized adults develop AKI	of AKI cases recognized late	annual U.S. AKI care costs

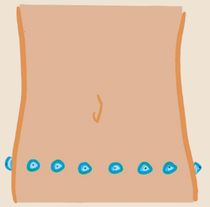
Our solution: Wearable device that collects bioimpedance measurements which translate into real-time urine output data.

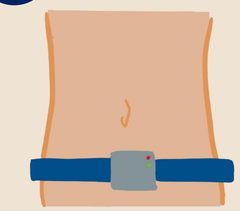
Key Features:

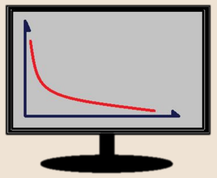
Continuous · Non-invasive · Accurate

Device Usage Process:

1. 
Peel 8 electrodes from backing

2. 
Apply the 8 electrodes on lower abdomen in this configuration

3. 
Snap on monitor device that calibrates to the patient

4. 
Continuous monitoring logged to EHR

Algorithm & Testing Results

Bioimpedance values were measured in real-time with the AD5940 analog front-end, which can support two voltage and two current electrodes. Urine output is derived from a self-developed algorithm that analyzes all 210 combinations of electrodes.

We expect bioimpedance to decrease as urine volume in the bladder increases, since urine is a conductive fluid. Bioimpedance values were refined by synthesizing data from eight adjacent electrodes, effectively mitigating interference caused by abdominal artifacts.

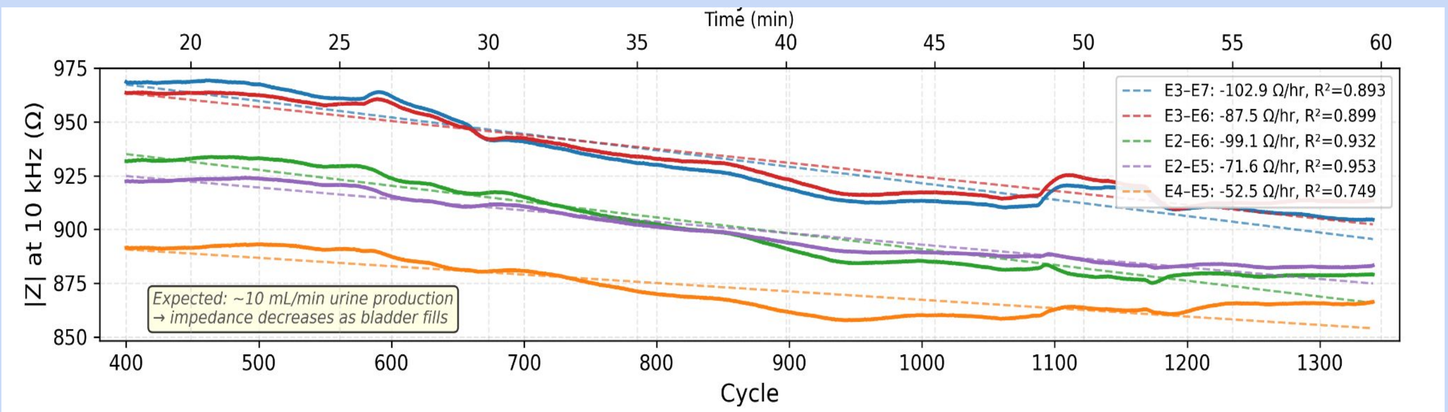


Fig. 1. Impedance measurements from multiple electrode configurations after user consumed 750ml water

References
1. Goyal A, Daneshpajouhnejad P, Hashmi MF, Bashir K. Acute kidney injury. PubMed. Published November 25, 2023. https://www.ncbi.nlm.nih.gov/books/NBK441896/:
2. Dheman K, Walser S, Mayer P, et al. Non-invasive urinary bladder volume estimation with artefact-suppressed bio-impedance measurements. arXiv.org. Published 2023. https://arxiv.org/abs/2303.14028