E93 A Comparison of Bioelectrical Impedance Analysis Techniques for Estimating Postmortem Interval (PMI)

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After attending this presentation, attendees will understand the use of Bioelectrical Impedance Analysis (BIA) for estimating the PMI using Accumulated Degree Days (ADD).

This presentation will impact the forensic science community by presenting developments in a new quantitative method for estimating PMI.

Methods for estimating PMI are an integral part of the medicolegal investigation. The probative value of PMI estimation necessitates eliminating subjectivity. Major confounding factors in PMI estimation include: (1) the lack of regionally specific models; and (2) the challenges associated with estimation in late stage decomposition. BIA was a novel approach proposed by Hansen et al. as a quantitative method for PMI estimation.[1] The method was based on the dielectric properties of biological tissue, which function as a resistor-capacitor circuit. Decomposition changes the circuit in ways that can be quantified using BIA. The goal of this research was to further develop BIA techniques for estimating PMI using BIA measurements and ADD.

BIA techniques using human donors were developed at the Forensic Investigation Research Station, Colorado Mesa University, Whitewater, CO. Two BIA measurement approaches, fixed-distance and variable-distance, were tested on different body segments in this study. Both approaches used hypodermic needles inserted subcutaneously. In the fixed-distance approach, the source and detecting electrodes were positioned at left and right midfemur and midhumerus. The circuit formed in tissue between the detecting electrodes and electrode distances did not vary among donors. In the variable-distance approach, larger body segments were isolated by positioning the electrodes at specific anatomical landmarks. Detecting and source electrodes were paired 10cm apart, and the distance between pairs varied among donors according to individual limb length. Three body segments were used: hand-foot, thigh-foot, and hand-shoulder. Resistance (R) and reactance (X_c) were measured using a single-frequency, 400µA, 50kHz BIA unit. An on-site weather station measured ambient temperature hourly. The daily mean temperature was used to calculate ADD. Total Body Scores (TBS) were calculated following Megyesi et al.[2] Measurements of R and X_c were derived to impedance (Z) and standardized by the distance between detector electrodes.

Linear Mixed Effects Models (LMEM) were used to estimate ADD. This statistical model permits repeated measurements on a single donor. The fixed effects were TBS^2 and Z. The random effects for both intercept and slope were Z and the individual Donor. Model estimates were evaluated by comparing observed ADD (x) versus predicted (y) ADD. Analyses were completed in Program R using the lme4 package.[3,4]

Fixed-distance BIA measurements were possible for a maximum ADD of 6,072 for the midfemur and 6,128 for the midhumerus. Variable-distance measurements were possible for a maximum ADD of 874 for the hand-foot, 874 for the thigh-foot, and 778 for the hand-shoulder body segments. Conditional R^2 for the LMEM were 0.91 for the midfemur, 0.89 for the midhumerus, 0.94 for the hand-foot, 0.95 for the thigh-foot, and 0.95 for the hand-shoulder. The observed ADD versus predicted ADD were similar to the 1:1 relationship for each body segment.

The development of BIA as a method for estimating PMI continues to show promise. Hansen et al. demonstrated that the approach can be used on human remains using gel pads.[1] Measurements using gel pads lasted 227 ADD. This study demonstrates that the use of needles with fixed-distance measurements has the potential for significantly longer PMI estimation. Both the fixed and variable measurements accurately estimate ADD, but differ in the period over which measurements were possible.

BIA demonstrates the potential to address two challenging factors in PMI estimation -— the lack of quantifiable methods and the challenge of estimating PMI in late stages of decomposition. As an objective measure of changes to body composition, BIA may be statistically combined with region-specific macromorphoscopic scoring models for more accurate PMI estimation; however, BIA approaches have not yet been subjected to blind validation tests and models are still being refined, necessitating further work.

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Reference(s):

1. Hansen E.S., Connor M.A., Baigent C.I. Bioelectrical Impedance Analysis as a Technique for Estimating the Postmortem Interval (PMI) in Human Remains. *Proceedings of the American Academy of Forensic Sciences*, 69th Annual Scientific Meeting, New Orleans, LA. 2017.
2. Megyesi M., Nawrocki S.P., Haskell N.H. Using accumulated degree-days to estimate the postmortem interval from decomposed human remains. *J Forensic Sci.* 2005; 5: 618-26.
3. R Core Team. 2017. *R: A language and environment for statistical computing.* R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.
4. Bates D., Maechler M., Bolker B., Walker S. Fitting linear mixed-effects models using lme4. *Journal of Statistical Software.* 2015;67(1):1-48. doi:10.18637/jss.v067.i01.

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