H15 Numerical Postmortem Interval (PMI) Estimation Streamlined for Forensic Practice: Combining Photogrammetry, Thermal Imaging, and Computed Tomography (CT)

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Learning Overview: After attending this presentation, attendees will have learned how computational algorithms and advanced imaging techniques can be combined to streamline numerical postmortem temperature-based PMI estimation for forensic practice.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by presenting, for the first time, an easy-to-use, accurate, and flexible method for temperature-based PMI estimation, potentially replacing the frequently inaccurate current gold standard.

The PMI represents crucial information in forensic investigations and can aid in the reconstruction of the timeline of events. Currently, this information is either guessed at or provided by an empirical model (Henssge's nomogram) based on a set of rectal temperature measurements performed under standardized experimental conditions. In practice, many forensic cases strongly deviate from these standardized conditions, rendering the model's PMI predictions largely inaccurate. A more rigorous and versatile approach to temperature-based PMI estimation was previously developed combining a comprehensive numerical (finite-difference) thermodynamic model and exterior (skin) temperature measurements. In this approach, a discrete (cubic) spatial grid is used to generate a 3D, computational representation of the body and its surroundings, enabling calculation of the heat exchange between the two. Here, this heat exchange is modelled as a combination of heat conduction, convection, and radiation; the body is approximated as an assembly of cones, ellipsoids, and cylinders (composed of adipose and non-adipose tissue) the proportions of which are dictated by standardized anatomical measurements (e.g., length of the arms and legs, as well as the circumference of the head, torso, upper arms, and wrists). Consequently, body posture, body dimensions, and environmental variables, such as contact surface, (partial) submersion in water, and (partial) coverage by clothes, are all readily included in the model. Knowledge of the thermal properties of the involved materials and timely probing of the heat exchange process (prior to thermal equilibrium) then allows the estimation of the PMI. Indeed, cooling curves measured on deceased human bodies are in close agreement with the model predictions yielding estimated PMIs within, at most, 2.7h of true PMIs between 7h and 20h. As a result, this approach is not only more versatile and widely applicable than Henssge's nomogram, but also outperforms it in terms of accuracy of the predicted PMI.

Despite the predictive capabilities of this approach, its laborious anatomical measurement routine renders application in forensic practice challenging. To address this challenge and streamline this technique, this study introduced photogrammetry-based generation of the model body. Here, the 3D shape of the body is reconstructed from a set of 2D images. This 3D information then serves to simultaneously render the dimensions and the posture of the model body in a robust and rapid manner. Furthermore, photogrammetry allows highly accurate spatial co-registration of measured and simulated skin temperatures through the use of coded imaging targets. This not only increases the PMI estimation accuracy, but also enables the integration of thermal imaging by the same token. As a result, this integrated approach requires minimal user input and physical contact. Besides accurately modelling the geometry of the body and its surroundings, it is crucial that the model's material composition closely resembles reality to ensure accurate simulation of the temperature evolution. An important factor in this effort is the body fat percentage, which was previously estimated using the United States Navy circumference method. In order to model the body composition more accurately, this study utilized PM CT scans to derive the 3D adipose tissue distribution that then served in the thermal property assignment for the model body. Similarly, this tomographic information also allows the modelling of body cavities filled with air (or other materials). Here, this presentation demonstrates the successful integration of co-registered photogrammetry, thermal imaging, and CT scans within a previously developed and validated finite-difference framework for numerical PMI estimation. Together, the versatility, limited required user input, and sample contact constitute the streamlined nature of this integrated approach and, consequently, establish its potential for future use in forensic practice.

PMI, Thermodynamic, Numerical

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