Decomposition Chemistry of Human Remains: A New Methodology for Determining the Postmortem Interval

Arpad A. Vass, Stacy-Ann Barshick, Gary Sega, John Caton, James T. Skeen, Jennifer C. Love and Jennifer A. Synstelien, Oak Ridge National Laboratory, P.O. Box 2008, Oak Ridge, TN 37831

To present to the forensic community a novel and accurate methodology for determining the post mortem interval.

This study was conducted to characterize the chemistry associated with the decomposition of human remains with the objective of identifying time-dependent biomarkers of decomposition. The purpose of this work was to develop an accurate and precise method for measuring the postmortem interval (PMI) of human remains. Eighteen subjects were placed within a decay research facility throughout the year and allowed to decompose naturally. Field autopsies were performed and tissue samples were regularly collected until the tissues decomposed to the point where they were no longer recognizable (encompassing a cumulative degree hour (CDH) range of approximately 1000 (3 weeks). Analysis of the biomarkers (amino acids, neurotransmitters and decompositional by-products) in various organs (liver, kidney, heart, brain, muscle) revealed distinct patterns useful for determining the PMI when based on CDHs. The initial results of this study demonstrated that one particular compound , oxalic acid, is an important determinant which affects PMI decisions. This compound was not initially targeted as important in PMI determinations, but was discovered incidentally. Oxalic acid derivatizes easily and is readily detectable in even the earliest tissue samples with a characteristic molecular ion of m/z=261. This compound, given time, then goes through a reduction reaction, apparently converting a C=O group to a methylene group producing an oxalic acid derivative with a molecular ion at m/z=247 and was subsequently identified as hydroxyacetic acid (glycolic acid). This reduction reaction occurs at different times (CDHs) depending on the tissue type and is an informative PMI indicator by itself.

Other important compounds, which have been found to be reproducible between corpses, include a variety of amino acids and gamma amino butyric acid (GABA). In order for a compound to be relevant for PMI determinations in this study, its ratio compared to other biomarkers must be reproducible over time. Initial tissue surveys indicated that the common, odoriferous amine indicators of decomposition, cadverine and putrescine, would be useful biomarkers. Unfortunately, this was not the case in this study. While the concentrations of these compounds were quite abundant (>3,000 ng/mg tissue) in some instances, the values (between corpses) were quite inconsistent as were the precursors of these compounds (lysine and ornithine). GHB was also a disappointment as a useful biomarker.

Since every death involves its own unique set of circumstances, the model was designed to take into account the many ways in which individuals perish. To accomplish this the model was developed to encompass more than one indicator organ. For instance, if the individual's heart was damaged by trauma, there are four other organs from which to obtain useful data. The more organs used, the narrower the PMI becomes. Crossmatching PMIs from several organs can result in intervals as narrow as five CDHs-a time frame below the ability of the investigator to obtain reliable temperature data. This model also has the distinct advantage that additional information about the victim, such as weight, is not required since the model was developed based on ratios between the biomarkers and not absolute values. One of the interesting results to emerge from this study was the observation that every organ studied produced such a varied assortment of complex biomarker information. Intuitively all the organs should possess a relatively similar composition. While the water content and assortment of cellular enzymes varies from organ to organ, the basic building blocks should be quite similar. During putrefaction, the abdominal organs (kidney, liver) are exposed to different bacterial populations than the thoracic organs (heart, lungs) and while this may produce varying results initially, it appears as if the tissue still exerts its 'personality' long after decomposition has progressed to the point where the organs are no longer recognizable.

It has been demonstrated that proper use of these methods allow for PMIs so accurate that the estimate is limited by the ability to obtain correct temperature data at a crime scene rather than sample variability.