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REVIEW ARTICLE

Unraveling the mysteries of decomposition: an in-depth look at thanatokymy

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ABSTRACT

Introduction: thanatochemistry is the discipline that studies the biochemical changes and evolution that occur in the cadaver, providing valuable information to support forensic diagnosis and the determination of the cause of death.
Objective: to analyze the different chemical compounds that are generated or modified in the human body after death, and their analysis to estimate the postmortem interval and the circumstances of death.
Methods: a literature review was conducted between January and February 2024 across various databases, which allowed the selection of 30 bibliographic sources after applying selection criteria. These sources were subsequently reviewed for critical analysis.
Development: thanatochemical determinations allow the identification of metabolites and decomposition products after death, providing information on causes and postmortem events. A challenge is the absence of databases to distinguish normal from pathological values. Among the most useful fluids, vitreous humor stands out as the ideal compartment for estimating the postmortem interval, especially through potassium measurement. Other samples include synovial fluid, urine, cerebrospinal fluid, and blood.
Conclusions: chemical changes after death can be identified through thanatochemistry. Vitreous humor is a reliable matrix, providing key information to estimate postmortem intervals and strengthen forensic and judicial investigations.

Keywords: Thanatokymy; Postmortem Changes; Thanatology; Postmortem Diagnosis.

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INTRODUCTION

Thanatochemistry, described for the first time in 1963, consists of the application of biochemical techniques for forensic purposes, used mainly in bodies with less than 24 hours since death to analyze organic and inorganic elements, with the purpose of establishing more precisely the time of death.[1,2] The determination of the postmortem interval is based on the study of physical and chemical transformations that occur from the moment of death until the autopsy, covering both early and late changes. However, this process often presents a challenge for forensic physicians, especially when there are no evident morphological or pathophysiological alterations. In such cases, postmortem biochemistry becomes an indispensable tool that provides objective parameters to support forensic analysis and help clarify the circumstances of death.[3]

Thanatochemistry, a branch of forensic medicine, is an essential tool in investigating the causes and circumstances of death, providing crucial information for the clarification of criminal acts, protection of public health, and pursuit of justice. It focuses on the study of chemical changes that occur in the organism after death, which allows determining both the cause and the postmortem interval (PMI), in addition to contributing to the identification of bodies and the resolution of criminal cases.[4,5]

Its application is especially valuable when pathologies do not present evident morphological alterations that explain the death process, as occurs in metabolic diseases, sepsis, hypothermia, or anaphylaxis. Nevertheless, this discipline faces limitations, since biochemical constituents, especially in blood, undergo postmortem alterations that hinder forensic interpretation and can generate controversy. Therefore, body fluids less susceptible to degradation or contamination have been prioritized, such as vitreous humor, cerebrospinal fluid, pericardial and synovial fluids, which offer greater stability and forensic value in evaluating biochemical parameters.[6]

The estimation of the time elapsed since death until the removal of the body (postmortem interval) has always been of great importance in legal medicine and forensics. Likewise, the estimation of PMI, in addition to evident ethical implications, has repercussions in both criminal and civil spheres. This information is useful for the various security forces and for the administration of justice, to determine the moment of death, especially to corroborate the truthfulness or congruence of a suspect's alibi.[7] This motivates the development of this study, whose objective was to analyze the different chemical compounds generated or modified in the human body after death and how these can be used to estimate PMI and the circumstances of death.

METHODS

The literature review was conducted between January and February 2024. The main descriptors used were the terms "thanatochemistry," "thanatology," and "postmortem biochemistry." The search was carried out in scientific databases specializing in health sciences and forensic medicine (PubMed, Scopus, ScienceDirect, and Google Scholar), applying Boolean operators (AND, OR) to combine descriptors and broaden the retrieval of relevant information. Original articles, systematic reviews, narrative reviews, book chapters, and documents from scientific societies published in Spanish and English were included, with no restriction on publication year, provided they addressed aspects related to postmortem biochemical changes and their application in forensic practice. Duplicates, brief communications, and articles without full text access were excluded.

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After reviewing the literature, 80 records were collected and, after duplicate removal, a total of 65 reviews were obtained. Subsequently, 20 works were excluded after evaluating publication dates, titles, and abstracts. Of the eligible full articles, 45 remained, and after applying inclusion and exclusion criteria, 30 references were finally selected, which were used for analysis and synthesis. A quantitative analysis was not performed due to the absence of studies meeting the methodological requirements for its application.

DEVELOPMENT

Thanatoquímica determinations should consider the changes that occur at death (that is, cessation of active membrane transport, loss of selective membrane permeability, cessation of metabolic activity); ideally, this is performed in an early PM interval before putrefaction. Regarding the identification of postmortem substances, the results can reveal the presence of various chemicals in the body after death. This may include the identification of metabolites, decomposition products, and other substances related to postmortem activity, which can provide valuable clues about the cause of death and the events that occurred after death of that cadaver, with the key point here that it can help distinguish between physiological postmortem changes and the presence of external substances that could have contributed to the death.[8,9,10]

Modifications in biochemical components after death, particularly in blood, are recognized, and often the findings of published investigations may generate discussion. Therefore, the importance of examining fluids that are not as easily affected or contaminated as blood after death is emphasized.[4]

A main challenge in thanatochemistry lies in the lack of a database containing the different biochemical elements needed to interpret them, which would allow distinguishing between normal and pathological. In addition to these three essential features, it is crucial to have knowledge of the behavior of these parameters after death and to ensure they are reliable. After a person dies, certain biochemical markers may undergo variations, either increasing or decreasing their levels depending on biological stimuli.[11,12]

In the realm of diseases that can be diagnosed through thanatochemical studies, cardiac pathologies stand out. The detection of specific biochemical markers in heart-associated tissues and fluids allows identifying conditions such as heart failure, coronary disease, or myocarditis. For this type of analysis, the most used samples are pericardial fluid and serum obtained from the femoral vein. Among the most relevant biomarkers is troponin I, recognized for its high specificity in detecting postmortem myocardial injury.[13,14,15,16]

Regarding the biochemistry of vitreous humor, the ideal analyte is one whose concentrations remain relatively constant in the population and whose variation with the postmortem interval depends mainly on the passage of time, minimizing the influence of other external factors. For this, a compartment protected from decomposition processes is required. The vitreous humor meets these conditions, establishing itself as a medium of great value for determining biochemical parameters and estimating the postmortem interval.[17]

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For an extended period, forensic pathologists have used postmortem biochemistry as a procedure to carry out medico-legal investigations to determine the true cause of death. It has been observed that, with proper handling, postmortem vitreous humor samples can reflect biochemical marker values similar to those of antemortem serum. However, preanalytical and analytical processes, such as handling, calibration, and validation of vitreous humor analyses, face some difficulties due to analytical issues specific to autoanalyzers adapted to measure serum and urine samples.[18,19]

Potassium levels (K+) are the most studied for estimating PMI. The concentration of this ion tends to increase after death, mainly due to diffusion from the retina and also from the lens. Since the 1960s, numerous studies have established a relationship between potassium concentration ([K+]) in the vitreous humor and the postmortem interval.[20,21] The relative rise in potassium is affected by high temperatures and exposure of the cadaver to those temperatures. A cadaver left at room temperature or higher for a substantial period will also rapidly progress through decomposition stages and further complicate the ability to use the vitreous humor for testing.[22,23]

Currently, the United States is one of the countries most actively conducting Thanatochemistry studies, as these are carried out in an integrated and advanced manner. The Federal Bureau of Investigation (FBI) plays a crucial role in this field, operating forensic laboratories spanning diverse disciplines, from forensic pathology to toxicology and DNA analysis. In addition to the FBI, each state has its own forensic system, with state laboratories that perform forensic analyses, including thanatochemical studies, to support local investigations.[17]

Forensic infrastructure, including the availability of laboratories equipped with up-to-date technology, could be a limitation in some places; this could affect the capacity to carry out thanatochemical analyses efficiently. It is essential to recognize that the constraints faced by our country can evolve over time, and countries have the capacity to develop strategies to overcome challenges. International cooperation and the pursuit of technical and financial assistance are equally important to improve forensic capabilities in Ecuador.[24]Still, our country conducts these studies, which we have seen are key when clarifying the cause of death of the cadaver; the tests include:

- Synovial fluid: after death, potassium and glucose values in synovial fluid undergo significant alterations. In particular, potassium concentration is considered a reliable parameter to estimate the postmortem interval. Several authors emphasize that this fluid constitutes an excellent matrix for postmortem biochemical analysis, especially regarding potassium.[6,25]
- Urine: in the field of postmortem biochemistry, urine has been used as support for the analysis of parameters such as ketones and glucose, establishing comparisons with vitreous humor in the diagnosis of diabetic ketoacidosis. [26]
- Cerebrospinal fluid (CSF): CSF is valuable for estimating the postmortem interval due to its low glucose concentration and relative stability. It also allows quantification of biomarkers such as enolase and brain creatine kinase, useful in anoxic and traumatic injuries, and to detect various causes of death through electrolyte and metabolite analysis. [27]
- Blood: it is the fluid most susceptible to hemolysis after death and to subsequent contamination. For this reason, in forensic biochemistry the use of vitreous humor, CSF, and synovial fluid is prioritized for evaluating biochemical parameters. [28]
- Vitreous humor: in forensic studies it is especially valuable, as its postmortem degradation is slow, it has low susceptibility to contamination, and it allows easy extraction. From this fluid, various biochemical parameters can be analyzed, including

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potassium, sodium, chloride, glucose, urea, and creatinine, useful for estimating the cause and the interval of death. These markers have been associated with pathologies such as asphyxiation, drug and alcohol use, dehydration, diabetic ketoacidosis, and natural deaths.[29,30]

CONCLUSIONS

Thanatochemistry plays a central role in forensic science by studying the chemical composition of the body after death, enabling the identification of toxic substances, diagnosing diseases, and pinpointing the causes of death. Its contribution is decisive for determining factors associated with death, establishing postmortem intervals, and providing objective support to judicial findings. By analyzing fluids and tissues, it offers reliable information that strengthens the investigation of crimes and the collection of scientific evidence. In this context, the study of vitreous humor stands out as an indispensable tool, as it provides detailed chemical data that contribute to reconstructing events at the crime scene, consolidating thanatochemistry as a comprehensive and precise resource in case resolution.

BIBLIOGRAPHIC REFERENCES

1. Bonifaz E. Tanatoquimia forense: Aplicación en determinación de causa y data de muerte [Tesis]. Quito; 2021 [citado 27/01/2024]. Disponible en: https://www.dspace.uce.edu.ec/server/api/core/bitstreams/755c6b0b-e57c-4e0c-9f27-e944fc70e637/content

2. Zhu BL, Cao ZP. Application of Postmortem Biochemistry Analysis in Forensic Medicine. Fa Yi Xue Za Zhi [Internet]. 2021 Dec 25 [citado 27/01/2024]; 37(6): 859-866. Disponible en: https://pubmed.ncbi.nlm.nih.gov/35243853/

3. Kutlu E, Avci E, Acar K. Postmortem biochemistry in deaths from ischemic heart disease. J Forensic Leg Med [Internet]. 2023 Nov [citado 27/01/2024]; 100: 102599. Disponible en: https://pubmed.ncbi.nlm.nih.gov/37839363/

4. Arroyo A, Carbone MT, Ordóñez J. Bioquímica postmortem: comparación de tres métodos de análisis. Cuad. med. forense [Internet]. 2004 Abr [citado 15/09/2025]; (36): 35-40. Disponible en: http://scielo.isciii.es/scielo.php?script=sci_arttext&pid=S1135-76062004000200005&lng=es.

5. Du TS, Mengxi MM, Ye X, Tu CY, Jin KD, Chen SW, et al. Research Progress of Metabolomics in Forensic Pathology. Fa Yi Xue Za Zhi [Internet]. 2020 Jun [citado 15/09/2025]; 36(3): 347-353. Disponible en: https://pubmed.ncbi.nlm.nih.gov/32705848/

6. Martín F, Matamoros M. Bioquímica Postmortem. Revisión Bibliográfica. Rev Cienc Forenses Honduras [Internet]. 30 de junio de 2019 [citado 15/09/2025]; 5(1): 21-9. Disponible en: https://www.bvs.hn/RCFH/pdf/2019/pdf/RCFH5-1-2019-6.pdf

ISSN: 1561-3194 **RNPS:** 1877
Rev Ciencias Médicas. 2025; 29(S1): e6871

7. Cunha CD. La bioquímica del humor vítreo en la data de la muerte y la práctica forense en Galicia: revisión sistemática y estudio descriptivo [Tesis]. 30 de junio de 2019 [citado 15/09/2025]. Disponible en: https://minerva.usc.gal/entities/publication/4195267b-4af7-4cbb-8cf5-e81d6424b333

8. Girlescu N, Stoica B, Hunea I, Diac M, Damian SI, David S, et al. The Vital Role of Thanatochemistry in the Postmortem Diagnostic of Diabetic Ketoacidosis-Case Report. Diagn Basel Switz [Internet]. 29 de mayo de 2021 [citado 15/09/2025]; 11(6):988. Disponible en: https://pmc.ncbi.nlm.nih.gov/articles/PMC8228401/

9. Elmsjö A, Vikingsson S, Söderberg C, Kugelberg FC, Green H. Post-Mortem Metabolomics: A Novel Approach in Clinical Biomarker Discovery and a Potential Tool in Death Investigations. Chem Res Toxicol [Internet]. 2021 Jun 21 [citado 15/09/2025]; 34(6): 1496-1502. Disponible en: https://pubmed.ncbi.nlm.nih.gov/33890460/

10. Elmsjö A, Söderberg C, Jakobsson G, Green H, Kronstrand R. Postmortem Metabolomics Reveal Acylcarnitines as Potential Biomarkers for Fatal Oxycodone-Related Intoxication. Metabolites [Internet]. 2022 Jan 25 [citado 15/09/2025]; 12(2):109. Disponible en: https://pubmed.ncbi.nlm.nih.gov/35208184/

11. Donaldson AE, Lamont IL. Biochemistry changes that occur after death: potential markers for determining post-mortem interval. PLoS One [Internet]. 2013 Nov 21 [citado 15/09/2025]; 8(11): e82011. Disponible en: https://pmc.ncbi.nlm.nih.gov/articles/PMC3836773/

12. Martínez Jiménez D. Estudio de la determinación postmortem de la adrenomedulina y otros parámetros bioquímicos en líquido pericárdico y suero: su aplicación al diagnóstico de la causa de la muerte [Internet]. Universidad de Murcia; octubre 2020 [citado 20/03/2024]; Disponible en: https://portalinvestigacion.um.es/documentos/615541a81fa5bb340fcbe6ba

13. Chen JH, Inamori-Kawamoto O, Michiue T, Ikeda S, Ishikawa T, Maeda H. Cardiac biomarkers in blood, and pericardial and cerebrospinal fluids of forensic autopsy cases: A reassessment with special regard to postmortem interval. Leg Med (Tokyo) [Internet]. 2015 Sep [citado 15/09/2025]; 17(5): 343-50. Disponible en: https://ouci.dntb.gov.ua/en/works/73agAOXl/

14. Sacco MA, Gualtieri S, Grimaldi G, Monterossi MD, Aquila VR, Tarallo AP, et al. The Role of Cardiac Troponins in Postmortem Diagnosis of Myocardial Ischemia: A Systematic Review. Int J Mol Sci [Internet]. 2024 Dec 26 [citado 15/09/2025]; 26(1):105. Disponible en: https://pubmed.ncbi.nlm.nih.gov/39795962/

15. Ma XY, Wang TQ, Tang KS, Yang YQ, Bai ZX, Zhang X, et al. Study on forensic diagnostic biomarker combination for acute ischemia heart disease based on postmortem biochemistry. J Forensic Leg Med [Internet]. 2025 [citado 15/09/2025]; 110: 102825. Disponible en: https://pubmed.ncbi.nlm.nih.gov/39919669/

16. Kutlu E, Çil N, Avci E, Bir F, Kiliç İD, Dereli AK, et al. Significance of postmortem biomarkers and multimarker strategy in sudden cardiac death. Leg Med (Tokyo) [Internet]. 2023 Mar [citado 15/09/2025]; 61:102212. Disponible en: https://pubmed.ncbi.nlm.nih.gov/36738552/

ISSN: 1561-3194 **RNPS:** 1877
Rev Ciencias Médicas. 2025; 29(S1): e6871

17. Carreiro da Cunha E. La bioquímica del humor vítreo en la data de la muerte y la práctica forense en Galicia: revisión sistemática y estudio descriptivo [Tesis]. UNIVERSIDADE DE SANTIAGO DE COMPOSTELA; 2021 [citado 20/03/2024]. Disponible en: https://minerva.usc.gal/rest/api/core/bitstreams/80a4aa6e-0f3d-4833-8fd4-c41c9dee9466/content

18. Jashnani KD, Kale SA, Rupani AB. Vitreous humor: biochemical constituents in estimation of postmortem interval. J Forensic Sci [Internet]. 2010 Nov [citado 15/09/2025]; 55(6): 1523-7. Disponible en: https://pubmed.ncbi.nlm.nih.gov/20666922/

19. Oblitas Falero YE. Descripción de la actividad de la isoenzima CKMB en humor vítreo en cadáveres con sospecha de infarto agudo de miocardio del instituto de medicina legal [Internet]. Universidad Privada Norbert Wiener; 2020 [citado 20/03/2024]. Disponible en: https://repositorio.uwiener.edu.pe/entities/publication/b9914866-9f87-48bc-99d8-18a7405aad48

20. Ravi Kumar B. Postmortem potassium kinetics in vitreous humor: a biochemical approach to time since death estimation in a forensic cohort. Int J Med Pub Health [Internet]. 2025 [citado 15/09/2025]; 15 (2): 1612-1615. Diaponible en: https://www.ijmedph.org/Uploads/Volume15Issue2/288.%202098._IJMEDPH_Jafar_1612-1615.pdf

21. Mihailovic Z, Atanasijevic T, Popovic V, Milosevic MB, Sperhake JP. Estimation of the postmortem interval by analyzing potassium in the vitreous humor: could repetitive sampling enhance accuracy? Am J Forensic Med Pathol [Internet]. 2012 Dec [citado 15/09/2025]; 33(4):400-3. Disponible en: https://pubmed.ncbi.nlm.nih.gov/22922550/

22. Guerrero-Urbina C, Fors M, del Sol M, Fonseca GM, Guerrero-Urbina C, Fors M, et al. Correlación entre Sodio, Cloro y Potasio del Cuerpo Vítreo y el Intervalo Postmortem sobre los 2.850 msnm. Int J Morphol [Internet]. abril de 2021 [citado 15/09/2025]; 39(2): 554-9. Disponible en: https://www.scielo.cl/scielo.php?script=sci_arttext&pid=S0717-95022021000200554

23. Ave MT, Ordóñez-Mayán L, Camiña M, Febrero-Bande M, Muñoz-Barús JI. Estimation of the post-mortem interval: Effect of storage conditions on the determination of vitreous humour [K+]. Sci Justice [Internet]. abril de 2021 [citado 15/09/2025]; 61(5): 597-602. Disponible en: https://www.sciencedirect.com/science/article/pii/S1355030621001003

24. Mendoza Lanche EF. La tanatoquimia diagnóstico complementario en la examinación de cadáveres para la determinación de su causa y data de muerte [Internet]. Machala: Universidad Técnica de Machala; 2022 [citado 21/03/2024]. Disponible en: https://repositorio.utmachala.edu.ec/bitstream/48000/19616/1/E-12839_MENDOZA%20LANCHE%20EINER%20FABRICIO.pdf

25. Vieira RB, Vicentin-Junior CA, Damascena NP, Silva MC, Araujo APD, da Trindade RQ, et al. Biochemical analysis of vitreous humor and synovial fluid in the estimation of early postmortem interval: A meta-analytical approach. J Forensic Leg Med [Internet]. 2024 Nov [citado 21/03/2024]; 108: 102782. Disponible en: https://pubmed.ncbi.nlm.nih.gov/39454520/

ISSN: 1561-3194 **RNPS:** 1877
Rev Ciencias Médicas. 2025; 29(S1): e6871

26. Rosato E, Bonelli M, Locatelli M, de Grazia U, Tartaglia A, Savini F, et al. Forensic Biochemical Markers to Evaluate the Agonal Period: A Literature Review. Molecules [Internet]. 2021 May 28 [citado 21/03/2024]; 26(11): 3259. Disponible en: https://pmc.ncbi.nlm.nih.gov/articles/PMC8198460/

27. Garland J, Philcox W, Kesha K, Morrow P, Lam L, Spark A, et al. Differences in Sampling Site on Postmortem Cerebrospinal Fluid Biochemistry: A Preliminary Study. Am J Forensic Med Pathol [Internet]. 2018 [citado 21/03/2024]; 39(4):304-308. Disponible en: https://pubmed.ncbi.nlm.nih.gov/30028732/

28. Belsey SL, Flanagan RJ. Postmortem biochemistry: Current applications. J Forensic Leg Med [Internet]. 2016 [citado 21/03/2024];41: 49-57. Disponible en: https://pubmed.ncbi.nlm.nih.gov/27131037/

29.Tumram NK, Bardale RV, Dongre AP. Postmortem analysis of synovial fluid and vitreous humour for determination of death interval: A comparative study. Forensic Sci Int [Internet]. 2011 [citado 21/03/2024]; 204(1):186-90. Disponible en: https://pubmed.ncbi.nlm.nih.gov/20638804/

30. Maeda H, Ishikawa T, Michiue T. Forensic biochemistry for functional investigation of death: concept and practical application. Leg Med (Tokyo) [Internet]. 2011 Mar [citado 21/03/2024]; 13(2): 55-67. Disponible en: https://pubmed.ncbi.nlm.nih.gov/21269863/