

AUTOPSIES IN FORENSIC PATHOLOGY – BETWEEN ADVANCES AND TRADITIONS

AUTÓPSIAS NA PATOLOGIA FORENSE – ENTRE AVANÇOS E TRADIÇÕES

AUTOPSIAS EN PATOLOGÍA FORENSE: ENTRE AVANCES Y TRADICIONES



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ABSTRACT

Autopsy, a *post mortem* examination, plays a crucial role in forensic and medical sciences, allowing for the clarification of causes of death and the investigation of pathological conditions. Traditionally, autopsy involves the dissection of organs for detailed assessment and has been a fundamental tool for diagnosis and medical learning. However, the rates of conventional autopsies have significantly declined, primarily due to advances in clinical diagnostics, regulations, and costs. In contrast, forensic autopsy remains relevant. In recent years, new modalities of autopsy, such as virtual autopsy, have emerged as promising alternatives. In this context, the objective of this study is to review the different approaches to autopsy, exploring the benefits and limitations of various autopsies in forensic and pathological contexts. Virtual autopsy uses advanced imaging technologies, such as *post mortem* computed tomography and magnetic resonance imaging, enabling non-invasive body evaluation. These techniques preserve the integrity of the corpse and have proven useful in various contexts by providing three-dimensional analysis and documentation of findings, although they have limitations, often related to the imaging method. Another emerging autopsy modality is molecular autopsy, which has proven crucial in investigating sudden deaths, especially in young individuals without comorbidities. This scientific research explores the autopsy in its duality, tradition, and modernity, in the advancement of forensic pathology and justice practices, considering the need for a balance between traditional and modern methods for a more comprehensive and accurate approach to *post mortem* investigations.

Keywords: Autopsy. Pathology. Forensic Imaging.

RESUMO

A autópsia, um exame *post mortem*, desempenha um papel crucial nas ciências forenses e médicas, permitindo o esclarecimento das causas de morte e a investigação de condições patológicas. Tradicionalmente, a autópsia envolve a dissecação de órgãos para avaliação detalhada e tem sido uma ferramenta fundamental para o diagnóstico e aprendizado médico.

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No entanto, as taxas de autópsias convencionais têm diminuído significativamente, principalmente devido ao avanço de diagnósticos clínicos, regulamentações e custos, em contraponto, a autópsia médico-legal segue relevante. Nos últimos anos, novas modalidades de autópsia, como a autópsia virtual, têm emergido como alternativas promissoras. Nesse contexto, o objetivo do presente estudo é revisar as diferentes abordagens de autópsia, explorando os benefícios e limitações das diferentes autópsias no contexto forense e da patologia. A virtópsia utiliza tecnologias avançadas de imagem, como tomografia computadorizada e ressonância magnética *post mortem*, permitindo a avaliação não invasiva do corpo. Essas técnicas preservam a integridade do cadáver e têm se mostrado úteis em contextos diversos pela análise tridimensional e documentação de achados, porém possui suas limitações, muitas vezes, ligadas ao método de imagem. Outra modalidade de autópsia emergente é a autópsia molecular, ela tem se mostrado crucial na investigação de mortes súbitas, especialmente em jovens sem comorbidades. Esta pesquisa científica explora a autópsia quanto sua dualidade, tradição e modernidade, no avanço da patologia forense e nas práticas de justiça. Considerando a necessidade de um equilíbrio entre métodos tradicionais e modernos para uma abordagem mais completa e precisa das investigações *post mortem*.

Palavras-chave: Autopsia. Patologia. Imageamento Forense.

RESUMEN

La autopsia, un examen *post mortem*, desempeña un papel crucial en las ciencias forenses y médicas, permitiendo esclarecer las causas de muerte e investigar afecciones patológicas. Tradicionalmente, la autopsia implica la disección de órganos para una evaluación detallada y ha sido una herramienta fundamental para el diagnóstico y el aprendizaje médico. Sin embargo, las tasas de autopsias convencionales han disminuido significativamente, principalmente debido a los avances en el diagnóstico clínico, la normativa y los costos; en contraste, la autopsia médico-legal sigue siendo relevante. En los últimos años, nuevas modalidades de autopsia, como la autopsia virtual, han surgido como alternativas prometedoras. En este contexto, el objetivo de este estudio es revisar diferentes enfoques de autopsia, explorando los beneficios y las limitaciones de las diferentes autopsias en el contexto forense y patológico. La autopsia virtual utiliza tecnologías de imagen avanzadas, como la tomografía computarizada *post mortem* y la resonancia magnética, lo que permite una evaluación corporal no invasiva. Estas técnicas preservan la integridad del cadáver y han demostrado ser útiles en diversos contextos mediante el análisis tridimensional y la documentación de los hallazgos; sin embargo, presentan limitaciones, a menudo relacionadas con el método de imagen. Otra modalidad emergente de autopsia es la autopsia molecular, que ha demostrado ser crucial en la investigación de muertes súbitas, especialmente en jóvenes sin comorbilidades. Esta investigación científica explora la autopsia en términos de su dualidad, tradición y modernidad, en el avance de la patología forense y las prácticas judiciales. Considera la necesidad de un equilibrio entre los métodos tradicionales y modernos para un enfoque más completo y preciso de las investigaciones *post mortem*.

Palabras clave: Autopsia. Patología. Imagenología Forense.

1 INTRODUCTION

The term autopsy literally means "to see for oneself" and would be equivalent to the term "*post-mortem*", "*post-mortem* examination" and necropsy. As an exam, it includes a detailed external evaluation, as well as a dissection of organs from different body cavities such as the skull, chest, abdomen and pelvis. Conventional autopsy each body cavity is rigorously examined in a systematic way to ensure that no detail is lost (Ayoub, 2008).

In many countries, including the United Kingdom, where consent is required, clinical autopsy rates performed, for example, by pathologies, have been declining since 1950. In contrast, autopsies still play a central role in forensic sciences. Even in teaching hospitals, autopsy rates declined to only 10% of deaths or even less ("*Autopsy*", 1987). Medical practice will be doomed to adverse consequences of these clinical actions or omissions. On the other hand, 20% of deaths are subject to medico-legal autopsies (Ayoub, 2008).

Within this context, new autopsy modalities have emerged, for example, the virtual autopsy. It is an innovative method, which has been solidifying its relevance, especially in the area of forensic imaging. It is noteworthy that there are several techniques and technologies used, but the greatest modern highlight is in *post-mortem computed tomography* and *post-mortem magnetic resonance*, which are capable of constituting relevant forensic elements for Forensic Pathology through images collected, in a non-invasive way and preserving the integrity of the corpse, in order to clarify the cause and circumstances of death, the identification of the corpse and the performance of thanatological and anthropological studies (Lopes, 2024).

Among the new technologies, molecular science has been evolving in an impressive way, including in the field of autopsies. A modality known as "molecular autopsy" refers to molecular tests performed *post-mortem* in order to accurately bring to light the probable *cause of death*, in addition to the pathogenic understanding behind the event, one of the possible uses of this autopsy modality is found in the investigation of causes of sudden deaths, and can go beyond the diagnosis of probable arrhythmia when no structural alterations are found that corroborate another pathological or forensic causal hypothesis of sudden death.

Based on this panorama, the importance of understanding this transition that is occurring in relation to autopsies is perceived. With this in mind, the objective of this scientific work is to study and explain about the traditional and modern autopsy, exploring the various aspects of it. The justification for the elaboration of this bibliographic review is based on the fact that this theme is a relevant agenda in the world of pathology and forensic sciences, lacking studies in order to fill the gaps still present on the subject.

2 DEVELOPMENT

2.1 TRADITIONAL AUTOPSY

The autopsy is an ancient technique, which for hundreds of years has helped us in the search to understand what led to a certain person's death. The information obtained not only instructs and confirms, but is also a path of study and a source of investigation. Despite the passage of centuries, they remain a necessary tool for elucidating the changing spectrum of diseases and causes of *death*. The purpose of the autopsy is not to point out to clinicians their mistakes or judge them, but rather to inform them so that they learn from their own mistakes. For example, knowledge of brain and heart diseases depends heavily on autopsies. (Ayoub, 2008)

The autopsy reflects the relevance of the autopsy as a diagnostic and educational tool in the medical environment. For many decades, autopsy rates have declined year after year, for various reasons. For example, clinical diagnostic advances, changes in regulations, and the impact of costs related to *post-mortem* procedures. However, this abandonment approach is not without harm, since this tool is extremely useful in a holistic analysis, for example, in the confirmation of clinical diagnoses and in the investigation of causes of death, helping to validate or correct treatments performed (Autopsy, 1987).

A specific use is made in the perinatal context, where perinatal autopsy shines as an extremely valuable tool in the investigation of fetal and neonatal death. When the autopsy is performed on the fetus or neonate, it is considered a perinatal autopsy. In general, defined as between 28 gestational weeks and one week of life, in the view of pathologists, it would be any fetal or neonatal autopsy. In general, it is performed by an interested, experienced pathologist with experience in the dissection of fetuses and neonates. The indication of this is variable according to gestational age, and may be performed due to fetal abnormalities or inevitable or repeated miscarriage, as well as fetal losses with no known explanation. Within this perinatal context, autopsies are described as highly complex, with pediatric pathologists pointing out as complex in more than 89% of the cases of performed, with detailed and detailed descriptions in order to collaborate with the pathological and panoramic understanding of the case (Ernst, 2015).

In China, a study brought the variations in autopsy rates over time in the country, highlighting sociocultural, medical, and legal factors that influenced these changes. Between 1950 and 2009, 4140 autopsies were performed at Zhejiang University, with the majority concentrated between 1960 and 1969. However, there was a sharp drop from 1990 onwards, with an average of only 10 annual autopsies in that decade. The results of the study show significant discrepancies between clinical diagnoses and autopsy findings. The overall

diagnostic error rate was 46.38%, reaching its peak between 2000 and 2009 (73.82%). The main causes of error included circulatory diseases (76.97%) and tumors (60.99%). This discrepancy persists even with technological advances, indicating challenges in clinical diagnosis in complex situations. In addition, factors such as cultural stigma, costs associated with performing autopsies, and fear of legal repercussions were also highlighted as barriers to their practice (Zhu, 2011).

2.2 MODERN AUTOPSY – VIRTOPSY AND OTHER MODALITIES

Modernity is surrounded by innovations, in relation to autopsies, this did not happen differently, new methods and models emerged to perform biopsies with or without going through the traditional invasive autopsy. From this point of view, the virtual autopsy, also known as *virtopsy*, shines. Studies point to the growing use of virtual autopsies as an alternative or complement to traditional autopsies in the forensic field. *Virtopsies* use advanced imaging technologies, such as post-mortem CT scans *and* post-mortem MRIs, to examine bodies non-invasively. These methods preserve the physical integrity of the corpse, making them particularly useful in cultural or religious contexts where invasive autopsies are prohibited (Levy, 2015; Lopes, 2024).

It is noteworthy that post-mortem computed tomography is highly effective in identifying fractures, pathological gases, large accumulations of fluids and calcifications, in turn, *post-mortem* magnetic resonance imaging has greater sensitivity in soft tissue lesions and myocardial infarctions (Bolliger, 2007). However, these technologies still have limitations such as the difficulty in detecting small thrombi or metabolic alterations due to the absence of intravenous contrast. In addition, subjective aspects such as texture and coloration, common in traditional autopsies, are lost in *virtopsies* (Lopes, 2024).

Virtopsy is escaping the theoretical model and gradually becoming a practical reality, certainly with its associated challenges. The possibility of performing an autopsy analysis without the need for invasive procedures allows flexibility in contexts in which a conventional biopsy would not be acceptable, as well as a more effective tool in thanatological and anthropological studies. *Post-mortem* computed tomography is more used in practice due to its efficiency in documenting bone and parenchymal system changes, while *post-mortem* magnetic resonance imaging is applied more selectively, such as in brain and heart studies (Contreras, 2012). However, challenges arise and include the difficulty of identifying vascular lesions and differentiating soft tissue interfaces. Therefore, complementary techniques such as postmortem angiography and guided percutaneous biopsies are being developed and improved to fill these gaps (Dirnhofer, 2006; Filograna, 2019).

An essential question regarding the understanding of virtopsy is its impact on the forensic sciences. It began through the Virtopsy® project, launched in the 1990s, which combined traditional autopsy methods with technologies such as computed tomography (CT), magnetic resonance imaging (MRI) and 3D scanning. These advances have made it possible to document the findings in a three-dimensional way, which can be reviewed by experts even after the cremation or burial of bodies. The agenda of limitations arises, with the use of other minimally invasive methods as mentioned, for example, post-mortem angiography and image-guided tissue collection for histological, toxicological and microbiological analyses as a possible solution (Lopes, 2024). These advances have not only been accepted as evidence in courts, but are also used to document injuries in living victims of violence, expanding their application in forensic medicine (Bolliger, 2015; Tejaswi, 2013; Thali, 2007).

One of the areas of forensic science that benefited from the use of virtopsy was particularly forensic dentistry. Traditionally, forensic dentistry autopsy involves the collection of visual, photographic, and radiological evidence on cadavers. However, the introduction of virtual autopsy, using high-tech radiological approaches, has provided a more efficient and accurate analysis of the cases investigated, especially in the identification of individuals through dental evidence, where the modern view complements the traditional approach (Chaves, 2022; Junior, 2012). Thus, the virtopsy becomes valuable, but does not supplant the conventional autopsy, especially when a more detailed examination of the tissues or an in-depth histological analysis is required (Silveira, 2021).

In addition to virtual autopsies, the molecular virtopsy modality has emerged, which is a postmortem approach that uses genetic testing to identify causes of sudden unexplained death, with special emphasis on young people without comorbidities that could somehow justify the event that occurred. Many cases of sudden death, especially in this juvenile population, have as an underlying cause a genetic etiology, such as hereditary arrhythmogenic syndromes, such as long QT syndrome) or cardiomyopathies. The contributions of molecular autopsy supplant only posthumous diagnoses, with contributions to living family members (Tester, 2012).

3 METHODOLOGY

It is a literature review according to a protocol previously written at the beginning of the review, which leads to a bibliographic search, carried out in a systematic way of the existing literature on the subject of research.

To prepare the research question, the PCC mnemonic (P - population/participants, C - concept and C - context) was used: "What virtual autopsy methods are being used in forensic pathology and what are their benefits in relation to traditional autopsy?"

Regarding the eligibility criteria, he was guided by the mnemonic itself. The population were corpses used in scientific research, for medical or forensic purposes. The concept was based on autopsies in the traditional model, complete or incomplete, and other modern autopsy models such as minimally invasive autopsy and virtual autopsy, also known as virtopsy. The context was limited to the studies published in the last 20 years that contemplate research on autopsy for forensic or non-forensic pathological purposes, providing a broad and comprehensive view of this modern question.

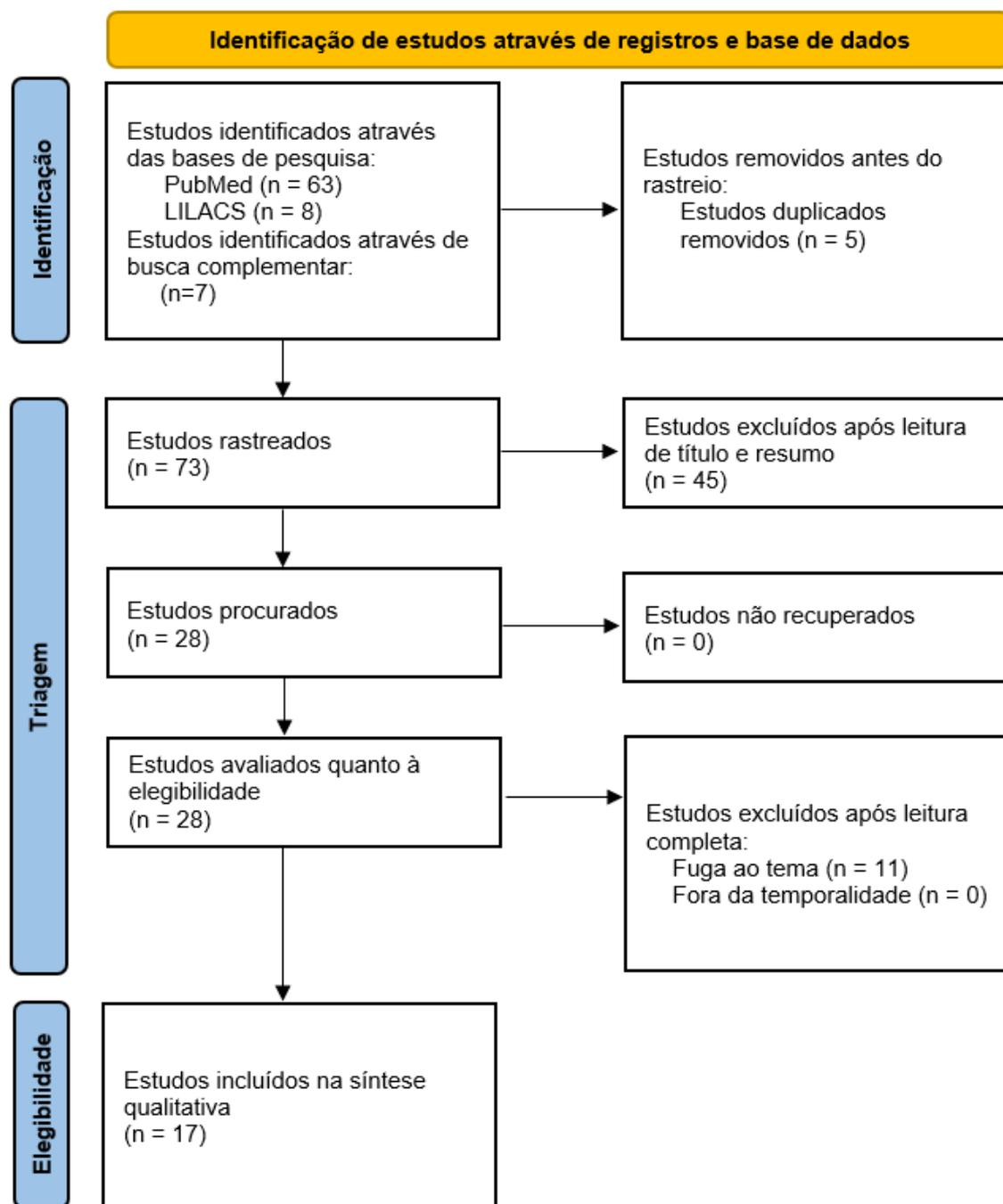
This literature review considered primary studies (original research) and secondary studies (systematic and non-systematic reviews) published or unpublished in national and international portals, repositories, and databases. Duplicates, non-full-text studies, and abstracts published in event proceedings were not considered.

The search strategy began with the identification of controlled descriptors (Mesh and DeCs) and non-controlled descriptors, designed from the keywords of the search question, used for the construction of the initial search strategy, combined or not, such as "Autopsia", "Autopsy", "Modern", "Modern", "Traditional", "Tradition", "Pathology", "Patology", "Forensic", "Forensic" and others. Through practical experience, the syntax was refined and the search strategies adapted to each database or data repository used. In the PubMed database, based on syntaxes and filters, a number (n) of 63 was found. In the LILACS database, based on syntaxes and filters, the number of 8 articles was found in the chosen time delimitation. In addition to the search in formal databases, a complementary investigation was carried out, including search syntaxes in journals, scientific journals and Google Scholar, in order to enrich and allow a more holistic and comprehensive analysis of the theme. Preprint databases were not searched.

The selection and screening stage of the studies took place in November 2024 and, after the searches, all the identified records were grouped. The first stage consisted of the removal of duplicates; then the title and abstract reading stage. Ultimately, the analysis of the text and references of the selected articles. The titles and abstracts, as well as the studies from the reference lists, were selected by an independent researcher, who evaluated the studies according to the eligibility criteria and the exclusion criteria.

Figure 1

Adapted PRISMA 2020 study flowchart



Source: Authors.

4 FINAL CONSIDERATIONS

Virtual autopsy, or virtopsy, offers a significant advance in the forensic field, providing objective and documentable data, minimizing the impact on the body, and respecting cultural sensitivities. Virtual autopsy is a non-invasive tool that can provide detailed three-dimensional images, allowing for a more objective and rapid assessment of trauma, injuries, and conditions that aid in criminal and scientific investigations. Studies, such as those presented here, reinforce the transformative role of technology in medical and forensic practice,

highlighting how virtual autopsies improve the accessibility, accuracy, and social acceptance of forensic methods.

In addition to its applicability in forensic medicine, virtual autopsy is a promising innovation in forensic sciences as a whole, also expanding its use in cases of autopsies performed by forensic dentists. This technology has shown the potential to transform investigative practices and contribute significantly to the advancement of forensic science, especially in the identification of victims, including identification by dental and anthropological parameters, helping to clarify complex cases.

However, its implementation faces barriers such as high costs, the need for specialized training, and technical limitations in complex cases, such as natural deaths or advanced decomposition conditions. To expand its use, efforts must be made to standardize protocols and integrate multidisciplinary teams, ensuring reliable and consistent results. In this way, the continued advancement of these tools can reduce economic barriers and make these practices more widely accessible, ensuring an even more significant impact on justice and medicine.

Regarding molecular autopsy, it represents a significant advance in forensic and preventive medicine, allowing to broaden the scope of postmortem diagnosis. However, its success depends on a multidisciplinary approach, which includes physicians, geneticists, and genetic counselors. Investments in accessibility, training, and awareness are also needed for this practice to become more widely used. The importance of integrating genetics and clinical medicine has come to light, both in postmortem assessment and in the protection of future generations.

It is also worth reflecting on the duality of traditional autopsy and modern autopsy, especially virtopsy. While virtual autopsy is a valuable tool, especially in terms of missing or minimal intrusion and digital documentation, it does not completely replace conventional autopsy. In fact, it provides flexibility and complementarity, each having its indications, and the combination of both methods can offer an effective complementary approach to forensic and medical diagnosis.

Thus, it is understood that the objective of this scientific manuscript is achieved while performing a bibliographic review based on the research question "What virtual autopsy methods are being used in forensic pathology and what are their benefits in relation to traditional autopsy?", bringing considerations about the theme based on this objective. Thus, helping to understand the importance of seeking the new, without suddenly abandoning the traditional. It is necessary that new scientific studies be carried out to further collaborate on

this complex theme in order to achieve a holistic understanding of the duality of traditional autopsy and autopsy in modernity.

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