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Systematic Review

Emergency Medicine Challenges in Medico legal Investigations: Microbiome Analysis in Postmortem Diagnostics

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ABSTRACT

Introduction: In criminal investigations, postmortem microbiology plays a crucial role because it helps in determining the cause and manner of death by revealing information about the microbial flora obtained from dead persons. With a focus on the methodology used, significant discoveries, and their consequences for forensic pathology, this systematic review attempts to thoroughly examine the body of research on postmortem microbiology in autopsy cases. ***Aim:*** This review assesses the current understanding of postmortem microbiology in autopsies, emphasizing microbial diversity, diagnostic reliability, and investigative significance. ***Methodology:*** A comprehensive search strategy will identify relevant studies published in peer-reviewed journals. Electronic databases such as PubMed, Scopus, and Web of Science will be systematically queried, using predefined search terms and inclusion criteria. Studies selected for inclusion will undergo a thorough quality assessment, and data extraction will be performed to summarize key aspects of study design, sample collection, microbial identification methods, and major findings. ***Result:*** The systematic review examined postmortem microbiology in autopsy cases, revealing diverse microbial communities with varied species across studies. Notable patterns emerged, highlighting the interplay of environmental factors and postmortem changes. Methodological differences existed in culture-based and molecular techniques, emphasizing regional disparities and postmortem interval effects. Valuable insights for forensic investigations were gained. ***Conclusion:*** In conclusion, this systematic review offers a thorough insight into postmortem microbiology in autopsy cases. It highlights dynamic microbial patterns, diagnostic technique reliability, and regional variations. While molecular advancements hold promise, standardization is crucial for optimal forensic application, enriching our understanding of postmortem investigations.

Introduction

Postmortem microbiology is a branch of microbiology and forensic pathology that is crucial in solving mysteries surrounding death and its causes. It involves the analysis of microorganisms present in the body after death to determine the cause and manner of death, estimate the time elapsed since death, and identify infections that may have contributed to death. Postmortem microbiology tests are one of the basic methods for diagnosing the etiology of infections in forensic pathology. The human microbiome can be used to indicate the t-ime elapsed after death, and machine learning approaches can be used to estimate the postmortem interval. The use of postmortem microbiologic cultures has been demonstrated to be of value in forensic investigations [1].

An autopsy is a meticulous examination of someone who died and is an essential component of forensic investigations that aim to clarify the cause and circumstances of death [2, 3]. Postmortem microbiology, an essential tool in forensic pathology, aids in determining the cause and manner of death. It involves analyzing microbial communities in the body after death, providing valuable information for forensic investig-

investigations. Despite the lack of standardization in sampling methods, postmortem microbiology is crucial for diagnosing infections, estimating the time since death, and identifying the effectiveness of antibiotic therapy. It can also reveal details on the postmortem interval and the presence of new pathogens, contributing to a better understanding of infectious diseases and forensic investigations. The value of postmortem microbiologic cultures has been demonstrated in forensic investigations, despite some controversy [4, 5]. **Figure 1** shows the assessment of the postmortem human microbiome and its diagnostic significance is depicted through the correlation of microbiological and histological data.

Forensic pathology, with its focus on understanding the physiological changes that occur postmortem, has increasingly recognized the importance of microbial involvement in the decomposition process [6]. The human body, a complex ecosystem teeming with microorganisms during life, undergoes a dynamic shift in microbial composition after death [7]. These microorganisms, once symbiotic or benign during life, transition into active participants in the decomposition process, influencing the trajectory of postmortem changes [8].

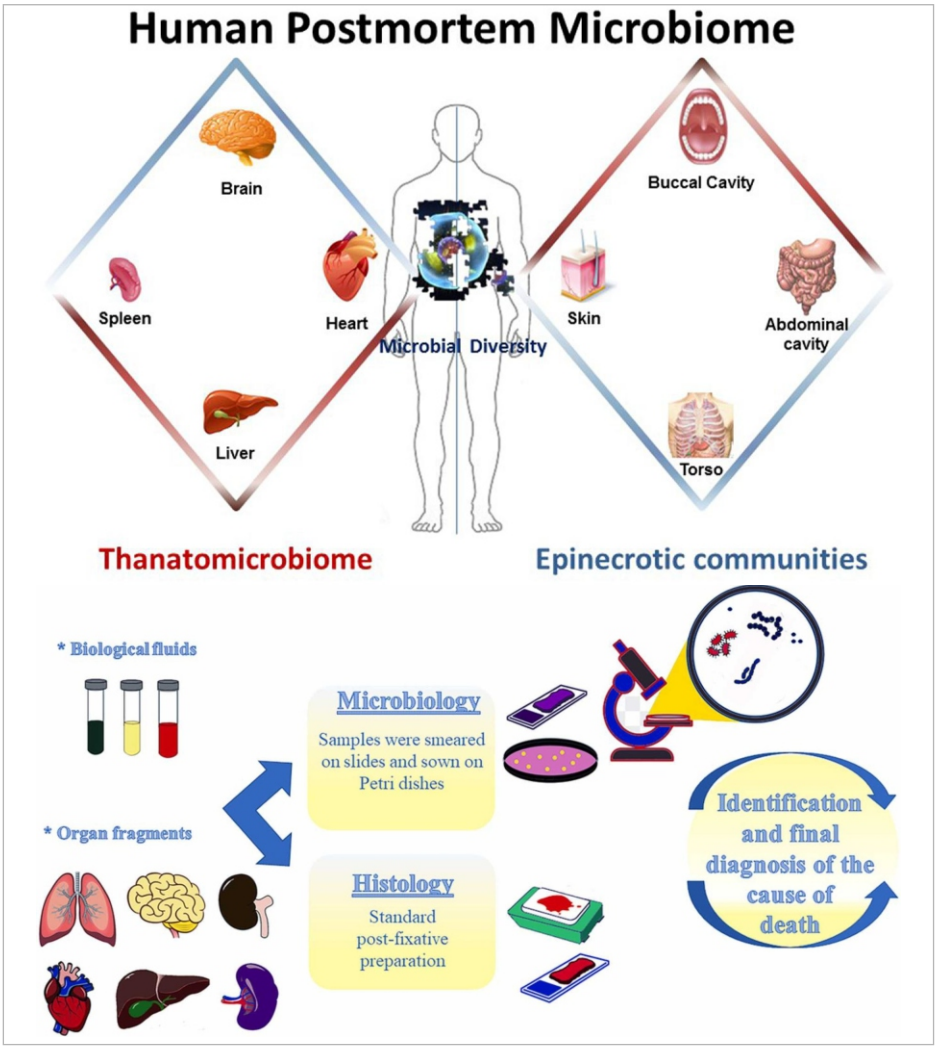

Figure 1: Evaluating human postmortem microbiome and diagnostic value through microbiology-histology correlation.

The study of the microbes that flourish in the postmortem setting is at the core of postmortem microbiology [9]. The human body suffers a metamorphosis due to the varied microbiota that arises after the breakdown of the host's immune system [10]. The original microbial makeup within the body, the postmortem delay, and environmental variables all have an impact on the microbial succession that occurs after death [11]. Acceptance of these complex dynamics is necessary to differentiate between prior medical conditions and postmortem changes improving the accuracy of forensic determination [12]. The reliability of diagnostic techniques in postmortem microbiology is a critical aspect that demands meticulous scrutiny [13]. **Figure 2** illustrating the possible uses of microbial forensics in handling criminal and legal investigations.

Traditional culture-based methods, though fundamental, may have limitations in detecting certain microorganisms and may be influenced by the viability of microbes in the postmortem period [14]. Molecular techniques, such as polymerase chain reaction (PCR) and next-generation seque-

sequencing, have emerged as powerful tools, enabling the identification of microbial DNA even in non-viable specimens [15,16]. However, the standardization and validation of these techniques in the postmortem context require careful consideration to ensure their applicability and accuracy [17]. Beyond the field of forensic pathology, microbiological results have great relevance in postmortem examinations. Significant information on the reasons leading to death can be obtained through the detection of certain bact-

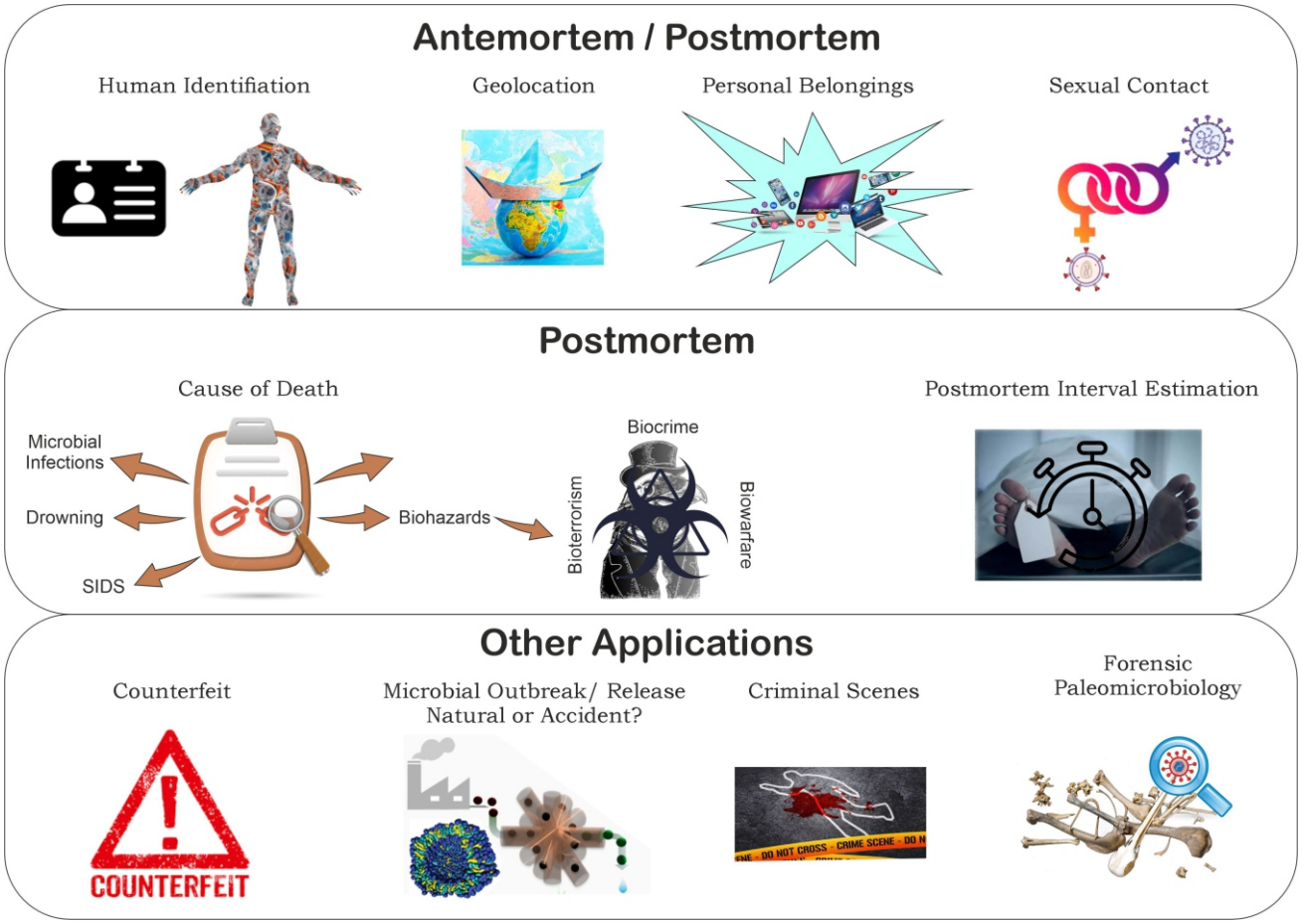

Figure 2: Visualization of potential microbial forensic applications for addressing criminal and legal inquiries.

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-eria and their growth patterns [18,19]. For example, the existence of some bacteria may be a sign of environmental conditions or postmortem interventions, whereas the lack of anticipated microbial alterations could cast doubt on the precision of the postmortem period calculation [20,21]. Moreover, postmortem microbiology has the potential to contribute to the understanding of infectious diseases, particularly in cases where conventional clinical diagnoses may be challenging [22].

The analysis of microbial communities in autopsied individuals can shed light on the epidemiology of infectious agents and their role in mortality [23]. This knowledge not only aids in public health surveillance but also contributes to the development of targeted preventive measures [24]. As the

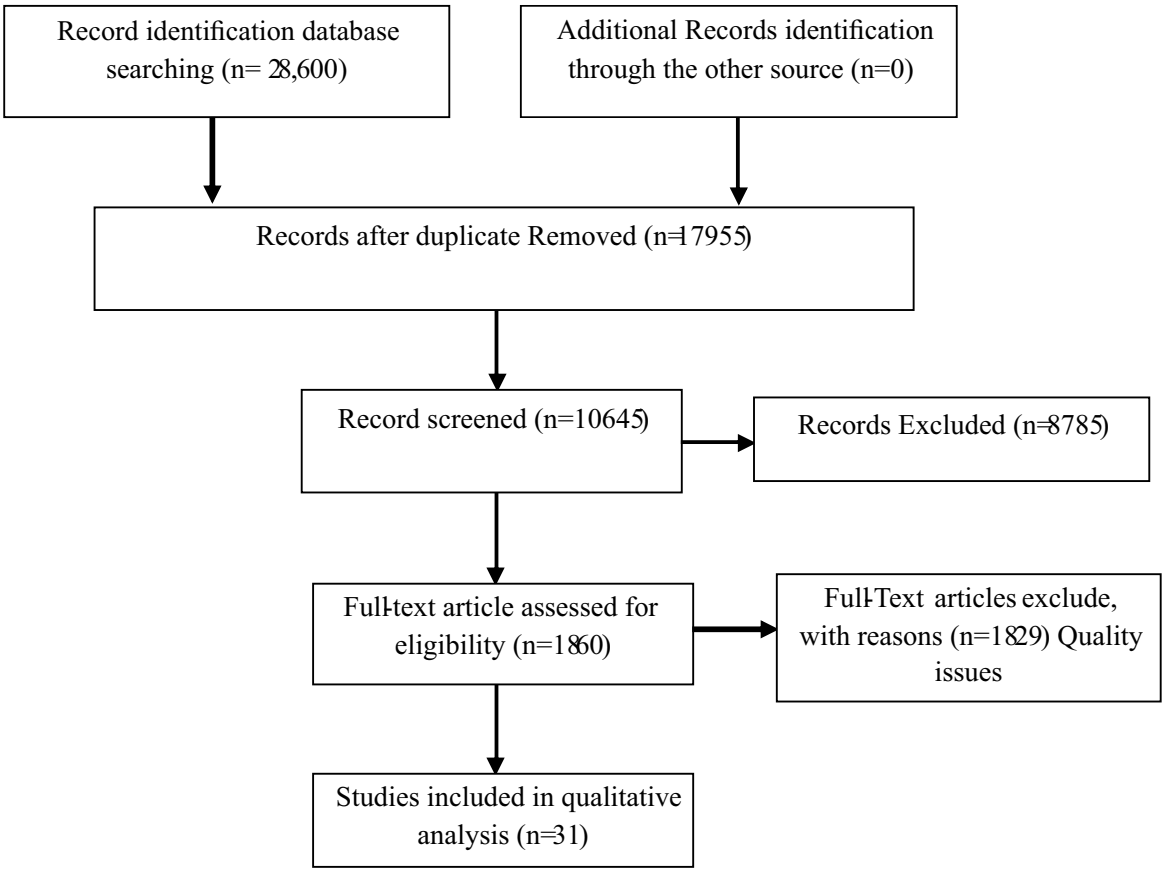
field of postmortem microbiology continues to evolve, it is imperative to critically evaluate the existing body of literature [25]. This systematic review endeavors to synthesize the findings of relevant studies, providing a comprehensive overview of the current state of knowledge. By scrutinizing the methodologies employed, the diversity of microbial communities identified, and the implications of these findings, this review aims to identify gaps in understanding and pave the way for future research directions.

METHODOLOGY

In this literature review, Bullion Words, a digital database, was used to search various publications, resulting in 28,600 hits. After careful consideration, 17,955 articles were selected as a representative sample. A further analysis narrowed the examination to 10,645 samples, with 8,785 disregarded due to download issues. After eliminating 1,860 articles for quality concerns, 1,829 underwent full-text analysis, leading to the final selection of 31 papers (n=31). T-

-he systematic review's methodology involves a meticulous approach to identifying, selecting, and analyzing relevant literature. A comprehensive search of electronic databases (PubMed, Scopus, Web of Science) will use predefined search terms. Inclusion and exclusion criteria will ensure the selection of studies pertinent to the review's objectives. The quality of selected studies will be assessed based on predefined criteria, and data will be systematically extracted, covering study design, participant demographics, postmortem intervals, sample collection, microbial identification, and key findings. Results will be synthesized, and subgroup analyses will explore microbial profile variations based on geographical location, postmortem interval, and sample types. The review will critically evaluate diagnostic techniques, emphasizing traditional culture-based methods and molecular approaches. Identifying research gaps and ethical considerations will be integral, ensuring a comprehensive and ethically sound synthesis of the current state of postmortem microbiology in autopsy cases.

Prisma Flow chart:



RESULTS

Postmortem microbiology stands as a crucial and insightful tool in the realm of forensic investigations, providing a wealth of information about the microbial communities that thrive in the postmortem environment. This systematic review of selected studies has unveiled a diverse and dynami-

-c landscape, showcasing the complexity of microbial compositions encountered in different scenarios. One of the key revelations from the review is the variability of identified microorganisms across studies. This diversity can be attributed to factors such as geographical locations, postmortem intervals, and the types of samples collected. Th-

-e geographical influence suggests that regional environmental conditions play a pivotal role in shaping postmortem microbial communities. Furthermore, differences in postmortem intervals underscore the dynamic nature of microbial colonization during various stages of decomposition.

The methods employed in these studies also revealed an intriguing dichotomy between traditional culture-based techniques and more advanced molecular approaches. Both methodologies offer unique insights into postmortem microbiology, yet their reliability can vary. This diversity in methodological approaches highlights the need for standardization in sampling techniques to ensure consistency and accuracy in findings. Despite the methodological variations, the collective findings contribute significantly to our nuanced understanding of postmortem microbiology. This knowledge, gleaned from diverse sources, enhances the forensic toolkit by providing valuable insights into microbial dynamics. These insights are particularly relevant for forensic investigations, where understanding the postmortem microbial landscape can aid in diagnosing infections, estimating the time since death, and evaluating the efficacy of antibiotic therapy.

The review also underscored the critical role of postmortem intervals in shaping microbial profiles. The temporal aspect of postmortem changes has a direct impact on microbial colonization patterns. This insight has practical implications in forensic contexts, where accurate estimation of the time since death is often a crucial component of investigations. Moreover, postmortem microbiology has the potential to reveal new information about infectious diseases and contribute to our understanding of emerging pathogens. The review highlights the importance of recognizing the value of postmortem microbiologic cultures in forensic investigations, despite occasional controversies. These cultures play a pivotal role in uncovering details about the postmortem interval, aiding in the identification of pathogens, and contributing to a comprehensive understanding of the complex interplay between environmental factors and postmortem changes.

This systematic review of postmortem microbiology studies provides a comprehensive overview of the field's current landscape. The findings emphasize the need for standardized methodologies, showcase the intricate relationship between environmental factors and microbial communities, and underscore the practical applications of postmortem microbiology in forensic investigations. This body of knowledge not only deepens our understanding of microbial dynamics in postmortem settings but also enhances the forensic community's ability to unravel the mysteries surrounding death.

DISCUSSION

In April 2014, Riedel S. and colleagues conducted a study that offers a comprehensive overview of literature-based evidence. The focus of this review is to assess the practical aspects and provide guidelines for individuals faced with the decision of permitting or discouraging the use of bacteriologic cultures in postmortem examinations. The study aims to contribute valuable insights to the ongoing discourse surrounding the utility of postmortem microbiologic examinations [26].

In 1965, O'Toole and collaborators published a study revealing that postmortem bacteriologic tissue cultures accurately indicated infection in only 44% of the cases they examined [27]. In a comprehensive review of 111 patients, Wilson et al. assessed the value of postmortem blood cultures in correlation with antemortem blood cultures. They found agreement in only 35% of cases, with postmortem cultures rarely providing clinically relevant information on the cause of death [28]. Carpenter and Wilkins conducted a retrospective review of over 2,000 autopsy cases. They found that the rate of positive postmortem blood cultures increased from 20% to 40%, correlating with the postmortem interval and early procurement of cultures within 18 hours after death. Additionally, their investigation into lung cultures revealed an increased positivity rate associated with the length of hospital stay and the postmortem interval before obtaining lung tissue for culture [29]. In 2023, Tambuzzi *et al.,* conducted a study on 45 cadavers undergoing judicial autopsy. The study categorized cases based on the presence or absence of autopsy signs suggesting infectious pathology. Microbiological and histological investigations were concurrently performed, revealing mono-bacterial, mono-fungal, mixed, and negative cultures. In mono-species growth, histological analysis confirmed infectious causes, while in mixed growth, the study distinguished between postmortal contamination and perimortem colonization. Cases with negative microbiology highlighted vital reactions to viral or parasitic infections [30]. In 2018, Pechal JL *et al.,* conducted a study revealing unique postmortem microbiomes in a large urban population. The microbiomes reflected antemortem health conditions within 24–48 hours of death. Results highlighted niche differentiation, microbial turnover, community stability up to two days postmortem, and a link between microbial biodiversity and antemortem health, including heart disease [31].

CONCLUSION

In exploring the intersection of Emergency Medicine challenges and Medico legal investigations, with a focus on Microbiome Analysis in Postmortem Diagnostics, this study underscores the intricate relationship between these domains. The dynamic nature of emergency situations, coupled with the legal complexities of postmortem investig--ations,necessitates a nuanced approach. Microbiome analy-

-sis emerges as a promising tool, offering valuable insights into the postmortem landscape. The challenges identified, ranging from time constraints to regulatory considerations, highlight the need for collaborative efforts between emergency medicine practitioners and forensic experts. Despite the hurdles, the potential benefits of incorporating micro biome analysis into postmortem diagnostics are significant, promising more accurate and detailed information.

RECOMMENDATION

Based on the findings, it is recommended that interdisciplinary collaboration between Emergency Medicine and Forensic Medicine be strengthened. Training programs should be devised to equip professionals with the skills to integrate micro biome analysis seamlessly into postmortem investigations. Standardized protocols and guidelines need to be established to navigate the medico legal landscape efficiently. Furthermore, policymakers and regulatory bodies should be engaged to address legal and ethical considerations surrounding the use of micro biome analysis in emergency medico legal cases. Research initiatives should be encouraged to expand our understanding of micro biome signatures in various emergency contexts, refining its applicability in diverse scenarios. Ultimately, the successful integration of micro biome analysis into postmortem diagnostics requires a concerted effort from both the emergency medicine and forensic medicine communities, ensuring that advancements in technology translate into improved outcomes for the deceased and enhanced clarity for legal investigations.

CONFLICT OF INTEREST

There is no conflict of interest.

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None

ETHICAL CLEARANCE

Not Applicable.

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