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The Role of Some Drugs in Modulating Corpse Decomposition Rate: A Medicolegal Perspective

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Abstract

Estimating the post-mortem interval (PMI) is crucial in forensic investigations, yet numerous factors, particularly drug presence, complicate its accuracy. Drugs influence decomposition by altering tissue chemistry, microbial activity, and arthropod colonization, leading to variations that impact forensic interpretations. This review explores drug-induced decomposition changes and their implications for forensic science. The increasing prevalence of polysubstance abuse and self-poisoning, particularly with pesticides, further complicates PMI assessments. Toxins and drugs significantly affect decomposition, potentially leading to inaccuracies in forensic evaluations. Traditional PMI assessment relies on indicators like body temperature, rigor mortis, livor mortis, and gastric contents. However, decomposition is influenced by microbial activity, which follows a predictable succession and serves as forensic evidence. Stimulants such as cocaine and methamphetamine hasten tissue breakdown, whereas opioids and barbiturates slow it. These variations complicate PMI estimation and highlight the need for forensic toxicologists to consider drug influences. Additionally, forensic entomology plays a role in PMI determination, as insects feeding on drug-exposed tissues exhibit altered life cycles. Understanding drug-induced decomposition changes is essential for accurate PMI estimation and forensic case resolution. Further research is needed to refine methodologies and improve forensic accuracy in medicolegal investigations.

Keywords Post-Mortem Interval, Forensic Entomology, Polysubstance Use, Cadaver Microbiome

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Introduction

The post-mortem interval (PMI) estimation is essential for criminal investigations in forensic science. Establishing PMI is one of the fundamental tasks of the forensic pathologist when a body is found However, several variables, such as the presence of medicines, might change the rate of decomposition, making PMI calculations more difficult. By altering tissue chemistry, arthropod colonization, or microbial activity, drugs can have an impact on decomposition. This article examines how certain medications affect decomposition and how these medications could be reflected in forensic investigations.

The World Drug Report estimates in 2015 that drug-related causes of death accounted for almost 450,000 deaths. 167,750 were directly linked to drug usage problems, mostly as a result of overdoses, of which 76% were caused by opioids. By 2022, it was estimated that nearly 292 million individuals, or 1 in 18, had used drugs globally. Cannabis remains the most widely used substance worldwide, with around 228 million users, while opioids come next with 60 million users. Thirty million individuals utilize amphetamine-type stimulants, whereas twenty million use "ecstasy" and another twenty million consume cocaine. [1]

Consumers currently have access to a broader range of medications, leading to more complex trends in addicted drugs. The use of multiple drugs is now common in most drug markets. Additionally, the World Health Organization (WHO) recognizes suicide as a public health concern, with more than 700,000 deaths related to suicide each year. It is believed that self-poisoning with pesticides accounts for 20% of global suicides, particularly in developing countries in Asia, Africa, and the Western Pacific area. [2]

It is widely recognized that the existence of toxins or drugs, regardless of their legality, in a corpse can change the speed and manner of decomposition, which can greatly affect the interpretation of forensic evidence. [3] Nonetheless, these effects remain mostly unclear, potentially leading to inaccurate and unquantifiable mistakes in calculating the postmortem interval (PMI). [4]

The PMI can typically be assessed fr om initial postmortem modifications, such a s the body’s temperature, eye changes, the e xistence and spread of muscle stiffness, the f orm and extent of livor mortis, and the state of ingested food in the digestive system duri ng the autopsy. [5]

Although these indicators offer valuable insights for determining the PMI, their precision can fluctuate significantly since decomposition is a complex biological and chemical process affected by environmental elements and the unique traits of the deceased. [6]

Decomposition

The natural process of death for a living organism includes several postmortem alterations, such as the cessation of immune function, fluctuations in temperature, and shifts in the development of commensal microbes. [7,8] Decomposition begins post-mortem, at which point cells undergo autolysis and emit various substances through lysozymes and other enzymes. [9,10] The method through which the soft tissues of the body deteriorate and turn into a skeleton is known as decomposition. [11]

Decomposition begins at the moment of death and is initiated by two processes: putrefaction, which involves the breakdown of tissues by bacteria, and autolysis, which entails the disintegration of tissues by the body's internal enzymes and chemicals. Substances such as putrescine and cadaverine are emitted during these processes, and they are primarily responsible for the notably offensive odor of decaying animal tissue. [12]

Anaerobic bacteria, primarily located in the stomach, produce gas during the breakdown process, leading to bloating. The bloating stage results from the release of vast amounts of hydrogen sulfide within the body's organs and cavities from bacterial growth in the anaerobic environment. This gas diffuses with ease through body tissue due to its small molecular structure. Gas accumulation within the body causes distension of the abdomen and swelling of limbs and facial structures Fluids are subsequently released, and nutrients along with germs are spread into the nearby soil. [13]

Given that the succession of microbial communities occurs in a fairly predictable manner, this microbial activity

suggests that bacteria may serve as valuable physical evidence in forensic investigations. After death, microbes (including bacteria and fungi) colonize carrion from a variety of sources during the decomposition process. The predictable succession of microbes could be useful for forensics, such as postmortem submersion interval estimation (PMSI) for aquatic deaths. [14]

Indeed, previous studies have demonstrated that the composition of the microbial community undergoes constant changes throughout the decomposition of land mammals, affecting internal organs, bones, and soils associated with the cadaver, as well as the skin, anus, mouth, nose, eye, and ear cavities. [15]

Furthermore, as people age, the dynamics of their human microbiome vary significantly in response to a variety of personal and environmental circumstances, such as intricate relationships between microbial activity, gastrointestinal illnesses, and medicinal medications. As well known, decomposition is an active ecological process influenced by several factors, including the environment, microbial actions, the existence of insects, relationships with vertebrates, and an organism's inherent characteristics. [16]

When a body is discovered in an advanced state of decomposition, it can be difficult to ascertain the cause of death, particularly when only skeletal remains are present. This is particularly accurate if the individual passes away from suicide or substance use in an isolated location. [17]

In these circumstances, insects serve as important forensic evidence for different toxicological assessments. Xenobiotics, comprising pharmaceuticals and various hazardous substances, are transferred to larvae while they consume cadaveric tissue. These substances may also transfer to other arthropods via the food chain. Up until now, toxins and medications have been discovered in insects. [18] Previous studies have also shown a potential link between the life stages of insects and the concentration of drugs in the substrate. [19]

Establishing the age of necrophagous flies is vital for providing support in PMI estimation of decaying bodies, as the growth patterns of young insects take place in a reliable fashion at a regulated temperature. [20]

Stages of Decomposition

In vertebrate animals, the decomposition process is typically categorized into five stages: fresh, bloat, active decay, advanced decay, and dry/remains. The two stages of chemical breakdown, autolysis, and putrefaction are integrated with the overall processes of decomposition. [21] These two stages assist in the disintegration of the body's main components via the chemical process of decay. After death, the microbiome of the living organism breaks down, and the necrobiome, which progresses predictably over time, replaces it. [22]

In contrast to a corpse placed underground or surrounded by specialized protective gear or items, a dead body exposed to media like air and water will decompose faster and attract significantly more insect activity. This is partly due to the cooler temperatures under the ground and the limited number of insects that can access it. [23]

Changes in postmortem microbial communities can be used by forensic scientists to calculate the period since death. [24] Anaerobic bacteria, mostly found in the stomach, create gas during decomposition, which causes bloating. Fluids are then released, and nutrients and germs are then dispersed into the surrounding soil. [25]

Because the succession of microbial communities occurs in a fairly predictable manner, this microbial activity suggests that bacteria can serve as valuable physical evidence in forensic analyses. [14]

Influence of Drugs on Decomposition

Substances influence the timing of insect life cycles differently, as shown by research on pharmaceuticals and illicit drugs found in animal remains. [26,27] For instance, maggots reared on tissues from rabbits injected with diazepam exhibited quicker growth rates and distinct pupa forms compared to the control group. [28] Moreover, medications can significantly alter the composition and function of our gut microbiota. [29,30] Research on the application of human or animal waste (including biosolids or reclaimed water) to land has demonstrated that the drugs and antibiotics found in these wastes can significantly alter the microbial communities in the soil; [31,32] Hence, it is highly probable that the surrounding microbiota in this environment would be influenced by pharmaceuticals or drug metabolites found in decomposing bodies. A change in these communities might eventually influence the rate or path of decomposition because insects and both the internal and external microbiomes play a role in it. Finally, no studies have directly associated the selection of scavengers consuming human body parts with individuals who have multiple medications in their system, existing diseases, or treatments.

Drugs can change the body's physiological and biochemical milieu, which can impact breakdown. The drug kind, dosage, and interactions with environmental factors all affect these outcomes. Cocaine can speed up decomposition by raising tissue acidity, boosting microbial activity, and drawing necrophagous insects sooner, according to studies. [32] Like cocaine, methamphetamine accelerates tissue degradation by promoting metabolic byproducts that support the growth of microorganisms. [7] Before death, these medications might delay decomposition and may result in a changed microbial population after death. They might also postpone the colonization of insects. [34] Preservatives, such as formalin and barbiturates can slow down decomposition and decrease microbial activity.

Drugs change the breakdown process by influencing the body's microbial flora. For instance, by decreasing microbial variety and activity, antimicrobial medications such as antibiotics might postpone decomposition. [35] Some medications affect how necrophagous insects behave. Cocaine, for instance, has been shown to draw blowflies (Calliphoridae) more quickly, while opioids may prevent or postpone insect colonization. [36] Drugs can alter the pH and chemical makeup of tissues, which can impact putrefaction and autolysis. Alkaline medications may slow down protein denaturation, whilst acidic medications may speed it up. [37]

The administration of fluoxetine affected the number and types of insects drawn to the treated carcasses, but it did not change the succession patterns of the insects. It similarly sped up the post-mortem decomposition process in the treated carcasses by 3 to 9 days when compared to the control group. When carcasses are subjected to direct sunlight, their rate of decomposition speeds up by approximately 14 to 16 days in contrast to when they are kept in the shade. [38]

The decomposition process is delayed by neurological and cancer medications compared with other end-of-life disorders,[39] neurological diseases were linked to a decline in the variety of soil microbial species. This implies that neurological medications might poison soil microorganisms, slowing down the pace of decomposition. In contrast to other end-of-life conditions, cancer was linked to a reduced rate of microbial respiration. This implies that cancer medications might poison soil microorganisms, slowing down the pace of

decomposition. In contrast to other end-of-life disorders, respiratory ailments were linked to an increase in soil microbial diversity. This implies that medications used to treat respiratory conditions can increase microbial diversity and accelerate the rate of breakdown.

Medicolegal Implications

Drug-induced variations in decomposition rates can make Post-Mortem Interval (PMI) estimations more difficult. Drug presence and its possible outcomes need to be considered by forensic investigators while examining the stages of decomposition. [40] Drugs found in bodily fluids and tissues can reveal information about the deceased's lifestyle, cause of death, and possible criminal conduct. Interpreting toxicological results is made easier by knowing how drugs affect breakdown. [24] Forensic research on cocaine usage revealed rapid decomposition, which, if left unaccounted for, might result in an underestimation of PMI. [41] On the other hand, delayed decomposition was seen in an opioid overdose instance, which called for modified PMI calculation techniques.[42]

The increase in drug-related deaths has influenced medico-legal investigations of fatalities. The speed of insect growth is significantly affected by substances present in a body, which in turn influences the pace of post-mortem decay and the evaluation of the post-mortem interval. This highlights the importance of forensic entomotoxicology, which investigates the influence of drugs and toxins on insect growth and succession trends. [38]

Traditionally, the post-mortem interval (PMI) is categorized into three phases: immediate, early, and late. The lack of blood flow and the impairment of regulatory systems are the primary reasons for the body's quick biochemical and physiological changes in the short term. The most apparent changes occur in the eyes and skin. 'Trucking' or the segmentation of retinal blood vessels is among the first noticeable signs in the eyes. During the ophthalmoscopic examination of the eyes, this symptom presents as a disruption in the unbroken column of blood. It typically occurs within 30 minutes after death, although it can sometimes take as long as two hours. [43] Other alterations in the eyes during the first post-mortem period include corneal clouding and a decrease in intraocular pressure. After death, the intraocular pressure drops sharply, reaching 4 mmHg or less six hours later. [44]

Within two hours of death, the cornea starts to fog, making it difficult to perform an intraocular inspection using an ophthalmoscope. Within the first few hours following death, the skin becomes pallid and loses its suppleness and gloss. However, a six-hour PMI histological analysis of the skin reveals no morphological alterations. [45] Other studies indicate an absence of cellular or biochemical alterations within 3 to 6 hours after death. [46]

Another technique for estimating the post-mortem interval is the evacuation of gastric contents. Light meals are expelled from the stomach in about 1 to 3 hours, and the timing of intake, if available – along with the meal's volume and type, can be utilized to gauge the post-mortem interval. [47] Consequently, the initial post-mortem period, occurring two to three hours following death and typically marked by an absence of significant morphological or histochemical changes, can be termed the post-mortem period between somatic and cellular demise.

The initial post-mortem phase is likely the most critical timeframe for estimating PMI since the majority of medico-legal cases are assessed during this period. This time frame is also when estimating the time since death becomes crucial for creating a timeline of events and formulating a theory regarding the circumstances of death. This timeframe lasts from 3 to 72 hours post-

mortem. The initial post-mortem stage is typically assessed using the traditional triad of post-mortem alterations – rigor mortis, livor mortis, and algor mortis. [48]

Algor mortis refers to the decrease in body temperature following death, primarily caused by the hypothalamus's failure to maintain homeostasis and the dissipation of heat to the environment through radiation, convection, and conduction. The most dependable method for assessing TSD during the initial post-mortem phase is algor mortis. Because of the numerous factors affecting the temperature difference between body heat and surrounding temperatures, with the primary one being changes in local temperatures over time, it is a challenging task that requires significant expertise and investigation before it can be applied effectively in practice. Typically, the temperature decreases by 1.5 degrees Fahrenheit each hour. [49]

Adenosine triphosphate (ATP), essential for the disassembly of actin-myosin filaments in muscle fibers, gets used up in the muscles, leading to rigor mortis, the stiffening of muscles after death. The components of muscle fibers, actin and myosin, come together when contractions occur. The cells' aerobic respiration ceases when the oxygen supply is interrupted, leading to inadequate ATP production. The "march of rigor" and Nysten's Law commonly explain the order in which rigor mortis starts immediately following death. Despite rigor mortis developing simultaneously in all muscle tissues of the body, both voluntary and involuntary, the examiner's capacity to notice alterations is influenced by the size of the muscle. Rigor mortis first appears in the smaller muscles around the face, including those near the lips, eyes, and various other features. It subsequently extends to the hands and upper extremities, and finally to the larger muscles of the lower limbs. Approximately two hours post-mortem, rigor mortis starts to set in within the facial muscles. In the next few hours, it extends to the limbs, concluding six to eight hours post-mortem. After an additional 12 hours (up to 24 hours after death), rigor mortis ultimately dissipates. [50]

Conclusion

Drugs play a serious role in adjusting the process of decomposition, with important consequences for forensic science. Exact interpretation of drug effects on corpse decomposition is essential for reliable PMI estimations and resolving medicolegal cases. Future research should focus on quantifying the specific impacts of various drugs across different environmental conditions to refine forensic methodologies.

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