Veterinary forensic medicine is the application of veterinary medicine to answer questions of interest to a court of law; it includes the examination and assessment of animals that have been or are suspected to have been injured or killed by an external influence. Veterinary forensic pathology is part of veterinary forensic medicine but deals specifically with the forensic postmortem examination of a deceased animal and is often performed by a veterinary pathologist. The veterinary pathologist not only performs the forensic postmortem examination (also known as the forensic autopsy or forensic necropsy) and documents examination findings but also participates in evidence collection and court proceedings, including giving depositions and trial testimony. Postmortem examinations may also be performed by a veterinary practitioner for a number of reasons, including lack of access to a veterinary pathologist and financial constraints.

Generally speaking, the veterinary pathologist will encounter a wide variety of forensic cases including those that involve sharp force trauma, projectile injuries, blunt force trauma, animal sexual abuse, intoxications, fire-related injuries, and neglect. Detailed discussion of these types of cases is beyond the scope of this article but is available in a number of reference textbooks.\(^1,2\)

When presented with an animal for forensic postmortem examination, the main question usually asked is what is the cause of death or injury. By definition, the cause of death is the injury or disease that produces a physiologic derangement in the body that results in the death of the individual.\(^3\) The cause of death can be further broken down into proximate and immediate. The proximate cause of death is the principal event that initiated the chain of events leading to death, and the immediate cause of death is the concluding or final event that actually
produces death. For example, for a dog that is shot in the abdomen and survives the gunshot injury only to die days later of septic peritonitis, the proximate cause of death is the abdominal gunshot injury and the immediate cause of death is the septic peritonitis. Were it not for the gunshot injury, the chain of events leading to death would not have transpired.

This article discusses the role of the veterinary pathologist during forensic investigations, including evidence collection and storage, and provides an overview of the forensic postmortem examination.

**EVIDENCE AND EVIDENCE MANAGEMENT**

Evidence can be defined as any information that can contribute to the legal standing of a case and is divided into 2 main types: physical and testimonial. The forensic postmortem examination concerns physical evidence. If collected and preserved correctly, evidence can make a case; conversely, evidence missed and/or mishandled can break a case. Evidence lost can never be recreated because the circumstances under which it is recovered are absolutely unique. Therefore, during a postmortem examination, the veterinary pathologist is charged with the responsibility of taking photographs, writing reports, and keeping evidence logs. To weaken the case against their client, defense counsel will actively look for cause to suppress the evidence or the testimony of an expert. Defense counsel may make motions to suppress the evidence in court, and the judge will rule on the admissibility of the evidence. As a consequence, crime laboratories and medical examiner offices/pathology laboratories use a number of systems to ensure that the evidence can be accounted for at all times and was tested as fairly as possible. Following these systems prevents the evidence from being suppressed on the basis of technicalities.

**Labeling**

The pathologist will label evidence with the purpose of furnishing basic information on the item of evidence and to uniquely identify evidence with the case information. A typical label will have the following information:

- Investigating agency name
- Item number
- Case number
- Date and time of collection
- Name of collector
- Brief description of item
- Location where item was collected
- Animal’s name and/or ID

Evidence collected during the postmortem examination is sealed in an evidence bag with special tamper-proof tape marked with the pathologist’s initials and the date of collection (FIGURE 1). Labeling is done half on and half off the edge of the tape, to make it easier to determine if any tampering has occurred.

**Chain of Custody**

The record of transmission and receipt of evidence is known as the chain of custody (COC). The purpose of COC is to document the care, custody, and control of each item of evidence at any point in time. COC documents can be used as evidence in a court proceeding to prove that evidence was handled properly. Although on the one hand adhering to COC principles can be viewed as a tedious process that creates extra work, it also serves to protect the investigating agency from accusation of mishandling/tampering with the evidence. Failure to maintain a link in the COC can result in evidence being thrown out on a technicality. For example, if a projectile recovered from the body of a dog is misplaced and cannot be accounted for at a particular point in time, defense counsel can ask for the evidence to be declared
inadmissible because the COC was broken. To avoid such an event from happening, it is important to maintain the COC from the moment the evidence is first collected by an investigator or pathologist until it is decided that the evidence is to be disposed of. Ideally, details surrounding the disposal should also be recorded on the COC form.

Storage
Different types of evidence require different storage conditions. For example, a bloodied item of clothing, collar, or harness is usually packaged in a paper bag to provide air and prevent mold growth, which can render biological evidence useless. Another basis for deciding which storage container should be used is size of the piece of evidence being stored. A tiny fiber found on the body during an examination requires storage vastly different from that of a bloodied collar. The fiber should be placed in a druggist's fold, which is then placed in an appropriately sized envelope. Because the body being examined is a potential source of trace and DNA evidence, the veterinary pathologist conducting a forensic examination should keep additional evidence collection tools on hand. It is also useful to keep COC forms on hand to fill out for any evidence recovered during the procedure, including formalin-fixed and fresh-frozen tissue samples.

FORENSIC POSTMORTEM EXAMINATION
The key differences between a forensic postmortem examination and a diagnostic postmortem examination are the purpose, documentation, and collection of evidence. Although the forensic postmortem examination differs in these respects, the dissection and examination of the body are nearly identical to those of a routine diagnostic postmortem examination. The forensic postmortem examination should consist of a thorough gross and microscopic examination of all major organ systems of the body. Its purpose depends on the requests of the investigator and is typically to determine the cause of death.

History and Death Scene Investigation
Before conducting the examination, the pathologist should make every effort to review a detailed history of events from the investigating officer. This history should include at least the animal signalment; location, date, and time at which the body was found; circumstances of the death; scene description; and description of body handling and storage. Depending on the case, the questions or issues of the investigation, and the documentation of the investigating agent, visiting the death scene may provide the pathologist with invaluable information that may not be completely captured by the investigator; however, in lieu of visiting the scene, the pathologist should be provided a copy of the investigator's report along with a written description and photographs of the scene and body in the position in which it was found.

External Examination
The external examination is often the most critical and time-consuming aspect of the forensic postmortem examination. It begins with documenting the manner and condition in which the animal was received from the submitter, describing any postmortem changes such as lividity (pooling of blood in skin and other soft tissues), rigor, decomposition, and/or insect activity. The pathologist then photographs all packaging materials and body surfaces, emphasizing unique markings, tattoos, or identification tags. The pathologist documents the animal's sex and body weight and scans the body for a microchip. The nutritional condition of the animal is described, and if a body condition score is provided, the system it is based on is noted. The condition and cleanliness of the hair coat, nails, ears, and teeth, and the presence or absence of any external parasites are described. Regions of body hair may be clipped or shaved to expose the skin surface over areas of interest.

All body orifices are evaluated for exudate, hemorrhage, or foreign materials. Any external wounds or injuries are thoroughly described and photographed; injury type, location, size, shape, and pattern are noted. Similarly, any evidence of medical or surgical intervention is documented. The pathologist palpates and examines all extremities for indication of internal injuries (e.g., crepitus, deformity, hemorrhage). Any abnormalities detected during external examination should be photographed and documented, using measurements from fixed body landmarks to indicate the location on the body.

Internal Examination
The internal examination begins by reflecting the skin to reveal the subcutis, preferably over the entire body,
but at least over the major body areas including the head, chest, abdomen, and any area with grossly visible external injury. The pathologist opens the body and examines all body cavities and organs. The organs from the cranial, thoracic, abdominal, and pelvic cavities are removed and examined, and the contents of any luminal organs are described. Special attention should be given to areas in which wounds, medical or surgical intervention, or other abnormalities are identified. An assessment should be made of the stores of internal adipose tissue and bone marrow. The pathologist may attempt to correlate internal injuries with external injuries by showing the spatial relationship between affected body areas.

Ancillary Techniques
Because each case is unique, numerous ancillary techniques can be used to further work up a forensic case in conjunction with the forensic postmortem examination. Commonly used ancillary techniques include radiography and other imaging, anthropology, toxicology, and histopathology.

Radiography and Other Imaging
Use of postmortem radiography and other imaging modalities (including computed tomography and magnetic resonance imaging) is extremely helpful during the forensic postmortem examination. It is imperative that postmortem imaging be performed for cases involving potential projectile injuries, blunt force trauma, fire-related deaths, and severely decomposed remains. Postmortem imaging can be used to identify metallic fragments from bullets and to identify pathology related to blunt force trauma.

Anthropology
For cases of traumatic injury, it may be beneficial to consult with an anthropologist to assist with osteologic trauma analysis. In these instances, bones may need to be prepared for analysis by use of various methods of tissue maceration (FIGURE 3) or dermestids (flesh-eating beetles).

Toxicology
One of the main tasks of the veterinary pathologist is to exclude or confirm toxic factors as the cause of death. Depending on the case information and the issues and circumstances surrounding the death, during the postmortem examination the pathologist may collect samples that are suitable for toxicologic analysis. In the case of a severely decomposed body, maggots recovered from the remains can be used as a potential specimen for toxicologic testing.13

Histopathology
Histopathology is the examination of tissues under the microscope to identify disease. In forensic cases,
histopathology can be used to verify, refine, or refute findings observed during the postmortem examination, as well as to identify pathologic findings not observed during the postmortem examination. Use of histopathology is not required for all cases; however, it should be mandatory when a cause of death is not determined during the postmortem examination, except in cases of examination of skeletal remains.

**DOCUMENTING FORENSIC POSTMORTEM EXAMINATION FINDINGS**

In addition to performing the forensic postmortem examination, veterinary pathologists must disseminate their findings in a manner that would be informative to all parties involved in the investigation. The pathologist has a number of ways to record information obtained during the postmortem examination, including written reports, photography, and use of body diagrams.

**Report**

The written report is the main method for recording postmortem examination findings. The postmortem examination is of little value if the pathologist cannot communicate his/her findings clearly, concisely, and accurately. Any interpretation(s) and opinion(s) rendered in a report must be formulated only after consideration of all available information.

There are 2 main report formats: free-style and printed proforma. The free-style report is written in the form of an essay, whereas a printed proforma has preprinted titles followed by blank spaces for insertion of examination findings. The report should not be limited to the description of “significant” findings because at the time of examination the significance of many lesions may not be known until further investigation by other parties. Regardless of the format of the report, it is imperative that the report is written in a timely manner.

**Photography**

During a forensic postmortem examination, use of photography is common. Photographs are a permanent record that can visually preserve encountered lesions. A good photograph will clearly demonstrate the lesion(s) of interest while minimizing distortion and misleading information. Photographs that rule out tissue abnormalities, called “negative photographs,” can be as valuable as photographs showing injuries. In veterinary forensics, the veterinary pathologist is trying to rule out injuries just as much as trying to rule them in.

**Body Diagrams**

Diagrams can be used to supplement the written report. Diagrams can be simple images of a generic animal’s body or can be more detailed (e.g., a diagram of the female reproductive tract). Examples of diagram uses include documentation of scars for cases of dog fighting, bruises, and gunshot injuries (FIGURE 4).

Because diagrams are traditionally printed in black, the color of the pen/marker used to write on the diagram should not be black in order to avoid confusion with the original lines of the diagram.

**ESTIMATING TIME SINCE DEATH**

Estimating the time since death, also known as the postmortem interval (PMI), is often valuable; however, the accuracy of estimating the PMI remains rather low. Although many techniques have been proposed, only a few are likely to be of practical use. Technique selection will vary according to the amount of time that has passed since death. In the early postmortem period, before the body has cooled to environmental

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**FIGURE 4.** Body diagram noting locations of scars on a dog’s body, including the head, chest, and forelimbs.
temperature, PMI estimation will probably be based on gross changes such as muscle rigidity and lividity, core temperature, and insect activity. In the late postmortem period, after the body has cooled, PMI estimation is often based on insect activity and other gross changes such as muscle rigidity and decomposition. Caution should be used when estimating PMI because it is dependent on numerous factors and its accuracy decreases as the actual time since death increases.17

Gross Changes

- **Lividity** appears as purple-red discoloration of the skin and other soft tissues in gravity-dependent locations. Lividity may begin within 30 minutes after death and in humans becomes completely developed at approximately 10 to 12 hours after death.18
- **Rigor mortis** is skeletal muscle rigidity that slowly develops in the jaw and limbs after death, resulting in immobility of these joints. After death, muscle cells continue to metabolize adenosine triphosphate (ATP), resulting in actin-myosin cross-bridging. However, because actin-myosin decoupling and muscle relaxation can no longer occur after stores of ATP are exhausted, muscle fibers remain in a state of permanent contraction. Full rigor lasts for a short time only and then fades away as the muscle begins to decompose. The onset and progression of rigor are variable and dependent on multiple factors.21 In humans, rigor mortis often begins approximately 2 to 6 hours after death, becomes fully developed by 6 to 12 hours, then begins to resolve by approximately 36 hours.19 In one study using dogs, diffuse rigor mortis was present at less than 1 day after death, and rigidity of the hind limbs and jaw persisted until 7 days after death.20
- **Green discoloration** of the skin may be seen at approximately 24 to 30 hours after death.21
- **Bloating** often develops at approximately 60 to 72 hours after death in humans and may occur faster or slower in other animal species and under various conditions. During this stage, red-brown liquid, called purge fluid, is produced and often leaks from body openings.18
- **Skeletonization** occurs several weeks to months after death.

Insect Activity

Insect activity has often extensively destroyed soft tissues by several days or weeks after death. Accurate interpretation of insect evidence relies on insect identification and weather data. Among the first insects to arrive on a dead carcass are blowflies.22 The time between death and arrival of the first blowflies is highly variable but may occur within seconds to minutes or may be delayed indefinitely.21 This time lag is a critical feature in the interpretation of insect evidence because insect evidence can be used only to calculate an estimated minimum PMI.19,21 Identification and evaluation of insects falls beyond the scope of practice of most veterinarians, and the reader is directed to other resources for further information.23,24

Temperature-Based Methods

The use of temperature-dependent methods requires a digital thermometer and a scale or weight tape for measuring body weight. To measure the core temperature of the body is measured by inserting the thermometer probe several centimeters into the rectum. The environmental temperature and body weight should also be measured. The collected data can then be applied to various formulae.11,21,25,26 These formulae are based on the principle that the body cools at approximately 0.5°C to 1.0°C (32.9°F to 33.8°F) per hour after death. In most cases, these calculations are not able to provide highly precise PMI estimations and should be used with caution.

CONCLUSIONS

The role of the veterinary pathologist in veterinary forensic investigations is critically valuable for animal cruelty investigations; open communication between the veterinary pathologist, veterinary practitioner, and investigators is essential. Veterinary pathologists are the subject matter experts with regard to postmortem disease diagnosis, interpretation of injuries, and cause of death determination. They can also perform the essential tasks of collecting evidence, writing postmortem examination reports, and testifying in court. As the recognition and investigation of crimes against animals continue to grow in our society, the demand for qualified veterinary pathologists is also expected to grow and their caseloads are likely to increase. Because a veterinary pathologist is not always available to assist with a forensic investigation, other veterinarians, such as shelter veterinarians, may be able to assist with forensic postmortem examinations. To best prepare for an investigation of a crime against an animal, any veterinary practitioner, legal practitioner, or investigator who anticipates submitting information about veterinary forensic cases is advised to contact a
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References


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