Euthanasia

Definition

The term euthanasia is usually used to describe ending the life of an individual animal in a way that minimizes or eliminates pain and distress.

When animals are plagued by disease that produces insurmountable suffering, it can be argued that continuing to live is worse for the animal than death or that the animal no longer has an interest in living.

The humane disposition is to act for the sake of the animal or its interests, because the animal will not be harmed by the loss of life. Instead, there is consensus that the animal will be relieved of an unbearable burden.

When the decision has been made to euthanize and the goal is to minimize pain, distress, and negative effect to the animal, the humaneness of the technique (ie, how we bring about the death of animals) is also an important ethical issue. As human beings it is our responsibility to ensure that if an animal’s life is to be taken, it is done with the highest degree of respect, and with an emphasis on making the death as painless and distress free as possible. When euthanasia is the preferred option, the technique employed should result in rapid loss of consciousness followed by cardiac or respiratory arrest and, ultimately, a loss of brain function. In addition, animal handling and the euthanasia technique should minimize distress experienced by the animal prior to loss of consciousness.

Evaluating methods of euthanasia

(1) Ability to induce loss of consciousness and death with a minimum of pain and distress

(2) Time required inducing loss of consciousness

(3) Reliability

(4) Safety of personnel

(5) Irreversibility

(6) Compatibility with intended animal use and purpose

(7) Documented emotional effect on observers or operators

(8) Compatibility with subsequent evaluation, examination, or use of tissue

(9) Drug availability and human abuse potential
(10) Compatibility with species, age, and health status

(11) Ability to maintain equipment in proper working order

(12) Safety for predators or scavengers should the animal’s remains be consumed;

(13) Legal requirements

(14) Environmental impacts of the method or disposition of the animal’s remains

Euthanasia methods are classified in the Guidelines as acceptable, acceptable with conditions, and unacceptable. Acceptable methods are those that consistently produce a humane death when used as the sole means of euthanasia. Methods acceptable with conditions are those techniques that may require certain conditions to be met to consistently produce humane death, may have greater potential for operator error or safety hazard, are not well documented in the scientific literature, or may require a secondary method to ensure death. Methods acceptable with conditions are equivalent to acceptable methods when all criteria for application of a method can be met. Unacceptable techniques are those methods deemed inhumane under any conditions or that the POE found posed a substantial risk to the human applying the technique. The Guidelines also include information about adjunctive methods, which are those that should not be used as a sole method of euthanasia, but that can be used in conjunction with other methods to bring about euthanasia.

CONSCIOUSNESS AND UNCONSCIOUSNESS

Unconsciousness, defined as loss of individual awareness, occurs when the brain’s ability to integrate information is blocked or disrupted. In humans, onset of anesthetic-induced unconsciousness has been functionally defined by loss of appropriate response to verbal command; in animals, by loss of the righting reflex. This definition, introduced with the discovery of general anesthesia more than 160 years ago, is still useful because it is an easily observable, integrated whole-animal response.

Anesthetics produce unconsciousness either by preventing integration (blocking interactions among specialized brain regions) or by reducing information (shrinking the number of activity patterns available to cortical networks) received by the cerebral cortex or equivalent structure.

PAIN AND ITS PERCEPTION

Criteria for painless death can be established only after the mechanisms of the mechanisms of pain are understood. The perception of pain is defined as a conscious experience. The International Association for the Study of Pain (IASP) describes pain as “An unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms
of such damage. Activity induced in the nociceptor and nociceptive pathways by a noxious stimulus are not pain, which is always a psychological state, even though we may well appreciate that pain most often has a proximate physical cause.”

**STRESS AND DISTRESS**

An understanding of the continuum that represents stress and distress is essential for evaluating techniques that minimize any distress experienced by an animal being euthanized. Stress has been defined as the effect of physical, physiologic, or emotional factors (stressors) that induce an alteration in an animal’s homeostasis or adaptive state. The response of an animal to stress represents the adaptive process that is necessary to restore the baseline mental and physiologic state. These responses may involve changes in an animal’s neuroendocrinologic system, autonomic nervous system, and mental status that may result in overt behavioral changes. An animal’s response varies according to its experience, age, species, breed, and current physiologic and psychological state, as well as handling, social environment, and other factors.

Stress and the resulting responses have been divided into three phases. Eustress results when harmless stimuli initiate adaptive responses that are beneficial to the animal. Neutral stress results when the animal’s response to stimuli causes neither harmful nor beneficial effects to the animal. Distress results when an animal’s response to stimuli interferes with its well-being and comfort. To avoid distress, veterinarians should strive to euthanize animals within the animals’ physical and behavioral comfort zones (eg, preferred temperatures, natural habitat, home) and, when possible, prepare a calming environment.

**MECHANISMS OF EUTHANASIA**

Euthanizing agents cause death by three basic mechanisms: (1) direct depression of neurons necessary for life function, (2) hypoxia, and (3) physical disruption of brain activity. The euthanasia process should minimize or eliminate pain, anxiety, and distress prior to loss of consciousness. As loss of consciousness resulting from these mechanisms can occur at different rates, the suitability of a particular agent or method will depend on whether an animal experiences distress prior to loss of consciousness.

**CONFIRMATION OF DEATH**

Death must be confirmed before disposal of any animal remains. A combination of criteria is most reliable in confirming death, including lack of pulse, breathing, corneal reflex and response
to firm toe pinch, inability to hear respiratory sounds and heartbeat by use of a stethoscope, graying of the mucous membranes, and rigor mortis. None of these signs alone, except rigor mortis, confirms death.

Methods of euthanasia

INHALED AGENTS

COMMON CONSIDERATIONS

Inhaled vapors and gases require a critical concentration within the alveoli and blood for effect; thus, all inhaled methods have the potential to adversely affect animal welfare because onset of unconsciousness is not immediate. Distress may be created by properties of the agent (eg, pungency, hypoxia, hypercarbia) or by the conditions under which the agent is administered (eg, home cage or dedicated chamber, gradual displacement or prefilling of the container), and may manifest itself behaviorally (eg, overt escape behaviors, approach-avoidance preferences [aversion]) or physiologically (eg, changes in heart rate, sympathetic nervous system [SNS] activity, hypothalamic-pituitary axis [HPA] activity)

The following contingencies are common to all inhaled euthanasia agents:

1. Time to unconsciousness with inhaled agents is dependent on the displacement rate, container volume, and concentration. An understanding of the principles governing delivery of gases or vapors into enclosed spaces is necessary for appropriate application of both prefill and gradual displacement methods.

2. Loss of consciousness will be more rapid if animals are initially exposed to a high concentration of the agent. However, for many agents and species, forced exposure to high concentrations can be aversive and distressing, such that gradual exposure may be the most pragmatic and humane option.

3. Inhaled agents must be supplied in purified form without contaminants or adulterants, typically from a commercially supplied source, cylinder, or tank, such that an effective displacement rate and/or concentration can be readily quantified. The direct application of products of combustion or sublimation is not acceptable due to unreliable or undesirable composition and/or displacement rate.

4. The equipment used to deliver and maintain inhaled agents must be in good working order and in compliance with state and federal regulations. Leaky or faulty equipment may lead to slow, distressful death and may be hazardous to other animals and to personnel.
Most inhaled agents are hazardous to animal workers because of the risk of explosions (eg, ether, CO), narcotics (eg, halocarbon anesthetics, CO2, asphyxiating gases), hypoxia (eg, asphyxiating gases, CO), addiction or physical abuse (eg, nitrous oxide [N2O], halocarbon anesthetics), or health effects resulting from chronic exposure (eg, N2O, CO, possibly halocarbon anesthetics).

In sick or depressed animals where ventilation is decreased, agitation during induction is more likely because the rise in alveolar gas concentration is delayed. A similar delayed rise in alveolar gas concentration can be observed in excited animals having increased cardiac output. Suitable premedication or noninhaled methods of euthanasia should be considered for such animals.

Neonatal animals appear to be resistant to hypoxia, and because all inhaled agents ultimately cause hypoxia, neonatal animals take longer to die than adults. Inhaled agents can be used alone in unweaned animals to induce loss of consciousness, but prolonged exposure time or a secondary method may be required to kill the unconscious animal.

Reptiles, amphibians, and diving birds and mammals have a great capacity for holding their breath and for anaerobic metabolism. Therefore, induction of anesthesia and time to loss of consciousness when inhaled agents are used may be greatly prolonged. Noninhaled methods of euthanasia should be considered for these species and a secondary method is required to kill the unconscious animal.

Rapid gas flows can produce noise or cold drafts leading to animal fright and escape behaviors. If high flows are required, equipment should be designed to minimize noise and gas streams blowing directly on the animals.

When possible, inhaled agents should be administered under conditions where animals are most comfortable (eg, for rodents, in the home cage; for pigs, in small groups). If animals need to be combined, they should be of the same species and compatible cohorts, and, if needed, restrained or separated so that they will not hurt themselves or others. Chambers should not be overloaded and need to be kept clean to minimize odors that might cause distress in animals subsequently euthanized.

Because some inhaled agents may be lighter or heavier than air, layering or loss of agent may permit animals to avoid exposure. Mixing can be maximized by ensuring incoming gas or vapor flow rates are sufficient. Chambers and containers should be as leak free as possible.

Death must be verified following administration of inhaled agents. This can be done either by examination of individual animals or by adherence to validated exposure processes proven to result in death.
If an animal is not dead, exposure must be repeated or followed with another method of euthanasia.

INHALED ANESTHETICS

Overdoses of inhaled anesthetics (eg, ether, halothane, methoxyflurane, isoflurane, sevoflurane, desflurane, enflurane) have been used to euthanize many species. Presently, only isoflurane, enflurane, sevoflurane, and desflurane are clinically available.

**Advantages**—(1) Inhaled anesthetics are particularly useful for euthanasia of smaller animals (<7 kg [15.4 lb]) or for animals in which venipuncture may be difficult. (2) Inhaled anesthetics can be administered by several different methods depending on the circumstances and equipment available (eg, face mask, open drop where the animal is not permitted to directly contact the anesthetic liquid, precision vaporizer, rigid or nonrigid containers). (3) Halothane, enflurane, isoflurane, sevoflurane, desflurane, methoxyflurane, and N2O are nonflammable and nonexplosive under usual clinical conditions. (4) Inhaled anesthetics can be useful as the sole euthanasia agent or as part of a 2-step process, where animals are first rendered unconscious through exposure to inhaled anesthetic agents and subsequently killed via a secondary method.

**Disadvantages**—(1) Inhaled anesthetics are aversive to rabbits and laboratory rodents and the same may be true for other species. Animals may struggle and become anxious during induction of anesthesia, with some animals exhibiting escape behaviors prior to onset of unconsciousness. Should apnea or excitement occur, time to loss of consciousness may be prolonged. (2) Ether is irritating, flammable, and explosive. Explosions have occurred when animals, euthanized with ether, were placed in an ordinary (not explosion-proof) refrigerator or freezer and when bagged animals were placed in an incinerator. (3) Induction with methoxyflurane is unacceptably slow in some species. (4) Because of design limits on vapor output, precision anesthetic vaporizers may be associated with a longer wash-in time constant and, thus, longer induction time; time to death may be prolonged as O2 is commonly used as the vapor carrier gas. (5) Nitrous oxide used alone will create a hypoxic atmosphere prior to loss of consciousness and will support combustion. (6) Personnel and animals may be injured by exposure to these agents. There is recognized potential for human abuse of inhaled anesthetics. (7) Because large amounts of inhaled anesthetics are absorbed and substantial amounts remain in the body for days, use of inhaled anesthetics for euthanasia is challenging for food-producing animals due to potential for tissue residues.

CARBON MONOXIDE

Carbon monoxide is a colorless, odorless gas that is nonflammable and nonexplosive at concentrations < 12%. Carbon monoxide is a cumulative poison that produces fatal hypoxemia; it readily combines with hemoglobin and blocks uptake of O2 by erythrocytes by forming carboxyhemoglobin.
Advantages—(1) Carbon monoxide induces loss of consciousness without pain and with minimal discernible discomfort, depending on species. (2) Hypoxemia induced by CO is insidious. (3) Death occurs rapidly if concentrations of 4% to 6% are used.

Disadvantages—(1) Carbon monoxide is an aversive agent for laboratory rodents and the same may be true for other species. (2) Safeguards must be taken to prevent and monitor exposure of personnel. (3) Electrical equipment exposed to CO (eg, lights and fans) must be spark free and explosion proof.

NITROGEN, ARGON

Nitrogen and Ar are odorless, colorless and tasteless gases that are inert, nonflammable, and nonexplosive. Nitrogen normally comprises 78% of atmospheric air, whereas Ar comprises less than 1%. These gases function in the current context by displacing air (and the O2 it contains), causing anoxia. Exposure of Sprague-Dawley rats to severe hypoxic conditions (< 2% O2) using either gas leads to unconsciousness around 90 seconds and death after 3 minutes using Ar or 7 minutes using N2141.

modify their behavior to avoid detrimental effects.

Advantages—(1) Nitrogen and Ar do not appear to be directly aversive to chickens or turkeys, and the resulting hypoxia appears to be nonaversive or only mildly aversive to these species. Similarly, N2 and Ar gas mixtures do not appear to be directly aversive to pigs and appear to reduce, but not eliminate, the behavioral responses to hypoxia.

(2) Nitrogen and Ar are nonflammable, nonexplosive, and readily available as compressed gases.

(3) Hazards to personnel are minimal when used with properly designed equipment.

(4) Argon and N2-CO2 gas mixtures are heavier than air and can be contained within an apparatus into which animals and birds can be lowered or immersed.

Disadvantages—(1) Hypoxia resulting from exposure to these gases is aversive to rats, mice, and mink.

(2) Based on the wash-in and washout functions, gradual displacement methods using N2 or Ar, alone or mixed with other gases, may result in exposure to hypoxic conditions prior to loss of consciousness. Loss of consciousness will be preceded by open-mouth breathing and hyperpnea, which may be distressing for nonavian species.

(3) Reestablishing a low concentration of O2 (ie, 6% or greater) in the chamber before death will allow immediate recovery.

(4) Exposure times > 7 minutes are needed to ensure killing of pigs.
(5) As with CO2, rats euthanized with Ar demonstrate alveolar hemorrhage consistent with terminal asphyxiation. Argon costs about three times as much as N2. These gases tend to cause more convulsive wing flapping in poultry than CO2 in air mixtures.

**CARBON DIOXIDE**

Inhalation of CO2 causes respiratory acidosis and produces a reversible anesthetic state by rapidly decreasing intracellular pH. Both basal and evoked neural activity are depressed soon after inhalation of 100% CO2. Inhalation of CO2 at a concentration of 7.5% increases pain threshold, and concentrations of 30% and higher cause deep anesthesia and death with prolonged exposure. Methods to administer CO2 include placing animals directly into a closed, prefilled chamber containing CO2, or exposure to a gradually increasing concentration of CO2.

*Advantages*—(1) The rapid depressant, analgesic, and anesthetic effects of CO2 are well established.

(2) Carbon dioxide is readily available in compressed gas cylinders.

(3) Carbon dioxide is inexpensive, nonflammable, and nonexplosive and poses minimal hazard to personnel when used with properly designed equipment.

(4) Carbon dioxide does not result in accumulation of toxic tissue residues in animals from which food is produced.

*Disadvantages*—(1) Substantial and conflicting differences in response to CO2 inhalation exist between and within species, strains, and breeds, making broad generalizations difficult.

(2) Carbon dioxide, whether administered by prefill or gradual displacement methods, can be aversive to some species, and therefore potential exists to cause distress.

(3) Because CO2 is heavier than air, layering of gas or incomplete filling of a chamber may permit animals to climb or raise their heads above the effective concentrations and avoid exposure.

(4) Immature individuals and some aquatic and burrowing species may have extraordinary tolerance for CO2.

(5) Reptiles and amphibians may breathe too slowly for the use of CO2.

(6) Euthanasia by exposure to CO2 with O2 supplementation may take longer than euthanasia by other means.

(7) Induction of loss of consciousness at concentrations < 80% may produce postmortem pulmonary and upper respiratory tract lesions.
(8) Dry ice and liquid CO2 are potential sources of distress or injury if permitted to directly contact animals.

NONINHALED AGENTS

COMMON CONSIDERATIONS

Noninhaled agents of euthanasia include chemical agents that are introduced into the body by means other than through direct delivery to the respiratory tract. The primary routes of their administration are parenteral injection, topical application, and immersion.

ROUTES OF ADMINISTRATION

Parenteral Injection

The use of injectable euthanasia agents is one of the most rapid and reliable methods of performing euthanasia. It is usually the most desirable method when it can be performed without causing fear or distress in the animal. When appropriately administered, acceptable injectable euthanasia agents result in smooth loss of consciousness prior to cessation of cardiac and/or respiratory function, minimizing pain and distress to the animal. However, heightened awareness for personnel safety is imperative when using injectable euthanasia agents because needle-stick injuries involving these drugs have been shown to result in adverse effects (41.6% of the time); 17% of these adverse effects were systemic and severe.

Intravenous injections deliver euthanasia agents directly into the vascular system, allowing for rapid distribution of the agent to the brain or neural centers, resulting in rapid loss of consciousness (for some invertebrates with closed circulatory systems, intrahemolymph injection is considered analogous to IV injection). When the restraint necessary for giving an animal an IV injection is likely to impart added distress to the animal or pose undue risk to the operator, sedation, anesthesia, or an acceptable alternate route or method of administration should be used. Aggressive or fearful animals should be sedated prior to restraint for IV administration of the euthanasia agent. Paralytic immobilizing agents (eg, neuromuscular blocking agents) are unacceptable as a sole means of euthanasia, because animals under their influence remain awake and able to feel pain.

Immersion

Euthanasia of finfish and some aquatic amphibians and invertebrates must take into account the vast differences in metabolism, respiration, and tolerance to cerebral hypoxia among the various aquatic species. Because aquatic animals have diverse physiologic and anatomic characteristics,
optimal methods for delivery of euthanasia agents will vary. In many situations, the immersion of aquatic animals in water containing euthanasia agents is the best way to minimize pain and distress. The response of aquatic animals to immersion agents can vary with species, concentration of agent, and quality of water; consideration of these factors should be made when selecting an appropriate euthanasia agent. Immersion agents added to water may be absorbed by multiple routes, including across the gills, via ingestion, and/or through the skin.

Ideally, immersion agents added to water will be nonirritating to skin, eyes, and oral and respiratory tissues and will result in rapid loss of consciousness.

**Topical Application**

Absorption of topically applied agents is slow and variable, making topical application an unacceptable means of efficient delivery of euthanasia agents for most animals. Exceptions include animals with highly permeable skin to which nonirritating, rapidly absorbed agents are applied (eg, amphibians euthanized with benzocaine gel). Currently there are no topical euthanasia agents that are US FDA approved for any species.

**Oral Administration**

The oral route has several disadvantages when considered for administration of euthanasia agents, including lack of established drugs and doses, variability in agent bioavailability and rate of absorption, potential difficulty of administration (including potential for aspiration), and potential for loss of agent through vomiting or regurgitation (in species that are capable of these functions). For these reasons, the oral route is generally unacceptable as a sole means of euthanasia, but may be an appropriate way to deliver sedatives prior to administration of parenteral euthanasia agents.

**PHYSICAL METHODS**

**COMMON CONSIDERATIONS**

Physical methods of euthanasia include captive bolt, gunshot, cervical dislocation, decapitation, electrocution, focused beam microwave irradiation, thoracic compression, exsanguination, maceration, stunning, and pithing.
Making a Decision Regarding Euthanasia

Have I gathered all the relevant information?

Euthanasia, using a systems view, is a process that involves pre-euthanasia and handling procedures, euthanasia methods and agents, confirmation of death and disposal of the remains. Am I adequately informed about these practical aspects?

Have I heard and considered all relevant reasons?

What should I consider before proceeding?

What is the animal's (current/future) quality of life?
Is the animal experiencing unremitting pain?
Can it be rehomed?

Do I have a conflict of duties between client, patient, other stakeholders, public health?

What are my professional obligations and my ethical commitments?
What is the most acceptable method and agent of euthanasia in this instance?

Other Basic Concerns (see also Part I of Guidelines)

Have I considered the worst case scenario?
Endeavor to avoid it.

Have I considered the best case scenario?
Endeavor to achieve it.