

EUTHANASIA

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Introduction and definition

- Many of the contents presented here are excerpts from **2000 Report of the AVMA Panel on Euthanasia (JAVMA 218 (5), 2001)**
- Euthanasia is a word of Greek origin, a rough translation being **Good death**
 - Webster English Dictionary
 - ❖ The act or practice of *painlessly* putting to death
 - Oxford English Dictionary
 - ❖ The action of inducing a *gentle* and *easy* death
 - Good death is one that occurs with minimal pain and distress
 - Euthanasia is, therefore, an act of inducing death in hopelessly unwell or injured animals in a pain free manner on the grounds of humanity

Criteria for evaluating methods of euthanasia

- It must be painless and not induce fear or apprehension in the animal
- It must be reliable
- It must be rapid
- It must be safe and simple to operate
- It must be nonreversible
- It should be inexpensive
- It should as far as possible be aesthetic
- It should be possible to observe the animals at all times
- It should be safe for predators/consumers should the carcass be consumed

Indications for euthanasia

- Required as an experimental procedure
- Sustained a severe injury that is difficult to manage
- The animal is in excruciating pain refractory to the treatment
- On demand by the authority (State or Federal inspectors, IACUC etc.)
- The colony may be at risk by an infected individual
- On economic grounds
- Approved for a research project to terminate the life

Methods of euthanasia

- The methods can be divided into **physical** or **chemical** methods
- Physical methods
 - Stunning
 - Gun shot
 - Captive bolt
 - Electrocutation
 - Cervical dislocation
 - Decapitation

- Chemical methods
 - Drug injections
 - Gas or vapor inhalation
 - Some chemical methods are only *conditionally acceptable* and should not be used as sole method for euthanasia

Selection/Application of euthanasia methods

- Unacceptable as sole method
 - Exsanguinations
 - Air embolism
 - Drowning
- Unacceptable injectable agents as sole method
 - Strychnine
 - Nicotine
 - Caffeine
 - Magnesium sulfate
 - Potassium chloride
 - Cyanide
 - Cleaning agents
 - Solvents
 - Disinfectants
 - Other toxins or salts
 - All curariform agents (neuromuscular blocker agents)
- Acceptable as sole method
 - Inhalant anesthetic overdose
 - Injectable anesthetic overdose
- Conditionally acceptable
 - Hypoxic gas mixtures with high concentration that result in rapid loss of consciousness followed by cardiopulmonary arrest or use of such mixtures in animals already under general anesthesia
 - Injectables such as potassium chloride in animals already under general anesthesia

Three basic mechanisms in terminating the life

Hypoxemia, direct or indirect

- CO₂
- N₂
- Argon
- CO

Direct depression of neurons vital for life function

- Anesthetics
 - Injectables & Inhalants

Physical disruption of brain activity & destruction of neurons necessary for life

- Stunning
- Gun shot
- Captive bolt
- Electrocutation
- Cervical dislocation
- Decapitation

Factors involved in the choice of euthanasia methods

- Species
- Age
- Size
- Temperament
- Health status
- Number of individuals
- Availability of materials and apparatus
- Reason for euthanasia
- Fate of the carcass
- Personal preferences
- Technical proficiency
- Compliance to the regulatory authorities (approval may be needed for research projects)

Inhalant agents

- Considerations
 - Speed of onset of loss of consciousness
 - Integrity of the equipment thoroughly checked prior to use
 - Hazard risk to the personnel
 - ✦ Explosion
 - ✦ Toxicity
 - ✦ Addiction
 - ✦ Hypoxemia
 - Noise
 - ✦ May frighten the animal

Inhalant anesthetic agents

- Ether, halothane, enflurane, isoflurane, sevoflurane, desflurane, methoxyflurane and N₂O
- Widely used across all species: reptiles, amphibians, and diving birds and mammals
- Advantages
 - Particularly valuable for smaller animals (< 7kg) or for animals in which venipuncture may be difficult
 - Halothane, enflurane, isoflurane, sevoflurane, desflurane, methoxyflurane and N₂O are nonflammable and nonexplosive under ordinary environmental condition
- Disadvantages
 - Struggling and becoming anxious during induction of anesthesia
 - Ether and methoxyflurane may be unacceptably slow in inducing loss of consciousness in some species
 - Nitrous oxide will support combustion
 - Personnel and animals can be at risk by exposed to these agents
 - A potential human abuse
- Recommendations
 - Inhalant agents are acceptable for euthanasia of small animals (<7kg).
 - Nitrous oxide should not be used alone
 - ✦ Even at 100 % the animal is not anesthetized and therefore hypoxemia develops prior to cardiopulmonary arrest
 - Although acceptable, these agents are generally not used in larger animal because of their cost and difficulty of administration

Carbon dioxide

- Advantages
 - Rapid depressant, analgesic and anesthetic effect of CO₂ are well established
 - Readily available and can be purchased in compressed gas cylinders
 - Inexpensive, noninflammable, nonexplosive and poses minimal hazard to personnel when used with properly designed equipment
 - No accumulation of tissue residues in food producing animals
 - No effect on murine cholinergic markers or corticosterone concentration
- Disadvantages
 - Heavier than air
 - ✦ Animal may climb above the CO₂ concentrated area and avoid exposure
 - Some species such as fish and burrowing and diving mammals, may have extraordinary tolerance for CO₂
 - Reptile and amphibians may breathe too slowly for use of CO₂
 - Slower onset than other inhalants
 - High concentration could be distressful to some animals
- Recommendations
 - Acceptable for euthanasia in appropriate species
 - Compressed CO₂ gas cylinders as the only recommended source of CO₂
 - ✦ CO₂ generated from other sources such as dry ice, fire extinguisher or chemical means (eg, antacids) is unacceptable
 - Species should be separated and chambers should not be overcrowded
 - Loss of consciousness may be induced more rapidly by exposing animals to a CO₂ concentration of 70% or more by pre-filling the chamber
 - Gas flow should be maintained for at least 1 minute after apparent clinical death

Nitrogen (N₂), Argon (Ar)

- Nitrogen and Argon are colorless, odorless gases that are inert, noninflammable and nonexplosive
- Euthanasia is induced by placing the animal in a closed container that has been pre-filled with N₂ or Ar, which displace O₂ inducing hypoxemia in animals
- Advantages
 - Both of these gases are readily available as compressed gases
 - Minimal personnel hazard
- Disadvantages
 - Loss of consciousness is preceded by hypoxemia and ventilatory stimulation, which may be distressing to the animal
 - Reestablishing a low concentration of O₂ (ie, 6% or greater) in the chamber before death will allow immediate recovery
- Recommendations
 - Can be distressful to some species (eg, rats)
 - ✦ Therefore, this technique is only conditionally acceptable if O₂ concentration less than 2 % is readily achieved, and animals are heavily sedated or anesthetized
 - Although effective, other euthanasia methods are generally preferred

Carbon monoxide

- Carbon monoxide is colorless, odorless gases that is noninflammable and nonexplosive unless concentration exceeds 10 %
- It combines with hemoglobin to form carboxyhemoglobin and blocks uptake of O₂ by erythrocytes, leading to fatal hypoxemia
- Advantages

- Induce loss of consciousness without pain and with minimal discernible discomfort
- Hypoxemia induced by CO is insidious so animal appears to be unaware
- Death occurs rapidly if concentrations of 4 to 6% are used
- Disadvantages
 - Safeguards must be taken to prevent exposure of personnel
 - Any electrical equipment exposed to CO (eg, lights and fans) must be explosion proof
- Recommendations
 - Personnel using CO must be instructed thoroughly in its use and must understand its hazards and limitations
 - The CO chamber must be of highest quality construction and should allow for separation of individual animals
 - CO chamber and source must be well lit and have view points that allow personnel direct observation of animals
 - Use for individual animal or mass euthanasia acceptable
 - CO should be provided with commercially compressed cylinder
 - CO source and chamber must be located in a well-ventilated environment
 - CO monitor in the room to warn personnel of hazardous concentration

Non-inhalant pharmaceutical agents

- Most rapid and reliable method
- Most desirable method
- Intravenous administration most effective in well restrained animals
- Intraperitoneal administration is acceptable if IV administration is impractical
- Intracardiac injection is acceptable only in heavily sedated or anesthetized animals
- Other non-vascular injections are not acceptable methods of administering injectable euthanasia agents

Barbituric acid derivatives

- IV administration
 - Rapid onset of action and loss of consciousness
- Depress the central nervous system
- With an overdose, deep anesthesia progresses to apnea, owing to depression of respiratory center, which is followed by cardiac arrest.
- Advantages
 - Speed of action depends on the dose, concentration, route, and rate of injection
 - induce euthanasia smoothly, with minimal discomfort to the animal
 - Inexpensive
- Disadvantages
 - IV injection is necessary
 - Each animal must be restrained
 - Controlled substance
 - Persist in the carcass and may cause sedation or even death of animals that consume the body

- Recommendations
 - IV injection is preferred in dogs, cats, other small animals, and horses
 - Intraperitoneal injection may be used in situations when an intravenous injection is distressful or even dangerous
 - Intracardiac injection must only be used if the animal is heavily sedated, unconscious, or anesthetized

Pentobarbital combinations

- Several euthanasia products are formulated to include pentobarbital, usually added with local anesthetic agents
- These combinations are listed by the DEA as schedule III drugs, making them somewhat simpler to obtain, store, and administer than scheduled II drugs such as sodium pentobarbital

Chloral hydrate

- Depresses the cerebrum slowly
 - Restraint may be a problem for some animals
- Death is caused by hypoxemia resulting from progressive depression of the respiratory center
 - May be preceded by gasping, muscle spasms and vocalization
- Recommendations
 - Conditionally acceptable for euthanasia of large animals only when administered IV, and only after sedation to decrease the aforementioned side effects
 - Not acceptable for dogs, cats, & other small animals as the side effects may be severe

T-61

- Injectable, nonbarbiturate, non-narcotic mixture of 3 drugs used for euthanasia
 - General anesthetic, curariform, and local anesthetic actions
- Not available in the US but available in Canada and other countries
- IV only
 - Onset of action of ingredients are different when administered other than IV routes

Tricaine methane sulfonate (MS 222, TMS)

- Euthanasia choice for amphibians and fish
- Concentration ≥ 250 mg/L concentration used for euthanasia
 - Fish should be left in this solution for at least 10 minutes following cessation of opercular movement
- Withdrawal time is 21 days, so inappropriate for euthanasia of animals intended for food consumption

Potassium chloride in conjunction with prior general anesthesia

- **Unacceptable** and condemned when used in **conscious** animals
- The use of fully saturated solution in anesthetized animals is an acceptable method to produce cardiac arrest and death
- One to 2 mmol/kg IV
- Advantages
 - Not controlled
 - Carcass less toxic for scavengers and predators
- Disadvantages
 - Rippling of muscle tissue and clonic spasms may occur on or shortly after injection
- Recommendations
 - Personnel performing this technique must be trained and knowledgeable in anesthetic techniques and correctly assess anesthetic depth prior to injecting the solution
 - Animal should be under surgical plane of anesthesia

Physical methods to disrupt brain activity

- Captive bolt
- Gunshot
- Cervical dislocation
- Decapitation
- Electrocution
- Microwave irradiation
- Kill traps
- Thoracic compression
- Exsanguination
- Stunning
- Pithing

Penetrating captive bolt

- Performed on ruminants, horses, swine, laboratory rabbits, and dogs
- Mode of action is concussion and trauma to the cerebral hemisphere and brainstem
- Adequate restraint is important
- A multiple projectile has been suggested to be more effective
- Advantages
 - An effective method for use when use of drugs is inappropriate in;
 - slaughter houses
 - research facilities
 - farms
- Disadvantages
 - Aesthetically displeasing
 - Death may not occur if equipment is not maintained and used properly
- Recommendations
 - An acceptable and practical method for horses, ruminants, and swine
 - Use of this method in other appropriate species is acceptable
 - Non-penetrating captive bolt must not be used as a sole method

A blow to the head

- Must be evaluated on the basis of the anatomic features of the species it is performed (eg adequate for young pigs but not for calves)
- Can be a humane method for neonatal animals with thin cranium
- Require trained personnel for proficiency
- Gunshot
- Advantages
 - Loss of consciousness is instantaneous
 - Given the need to minimize stress induced by handling and human contact, gunshot may at times be the most practical and logical method of euthanasia of wild or free-ranging species
- Disadvantages
 - May be dangerous to personnel
 - Aesthetically unpleasant
 - Under field conditions, it may be difficult to hit the vital target area
 - Brain tissue may not be able to be examined for evidence of rabies infection or chronic wasting disease when the head is targeted

Cervical dislocation

- Used for many years, when performed by well-trained individuals, appears to be humane
- Used for many years for poultry, other small birds, mice, and immature rats and rabbits
- Advantages
 - Induce rapid loss of consciousness
 - Does not chemically contaminate tissue
 - Rapidly accomplished
- Disadvantages
 - Aesthetically displeasing
 - Requires mastery of the skills
 - Use is limited to poultry, small birds, mice and immature rats and rabbits

Decapitation

- Used to euthanize rodents and small rabbits and research settings
- The tissues are chemically uncontaminated and brain tissues are intact
- Guillotines designed to accomplish decapitation in rodents and small rabbits are commercially available
- Advantage
 - Rapid loss of consciousness
 - Chemically not contaminate tissues
 - Rapidly accomplished
- Disadvantages
 - Handling and restraint required to perform this technique may be distressful to animals
 - Interpretation of the presence of electrical activity in the brain following decapitation has created controversy and its importance may still be open to debate
 - Personnel performing this technique should recognize the inherent danger of the guillotine and take adequate precautions to prevent personal injury
 - Decapitation may be aesthetically displeasing
- Recommendations
 - Conditionally acceptable if performed correctly and it should be used in research settings when its use is required by the experimental design and approved by the institutional animal care and use committee (IACUC)
 - Regular service to ensure sharpness of the blade
 - The use of plastic cones to restraining appears to reduce distress from handling, minimize the chance of injury to person, and improves positioning of the animal in the guillotine.
 - Those responsible for the use of this technique must ensure that personnel who perform decapitation techniques have been properly trained to do so

Electrocution

- Alternating current is used
- Induces death by cardiac fibrillation, which causes cerebral hypoxia.
- However, animals do not lose consciousness for 10 to 30 seconds or more after onset of cardiac fibrillation
- It is imperative that animals be unconscious before being electrocuted
- Advantages
 - Humane if the animal is first rendered unconscious
 - Does not chemically contaminate tissues
 - Economical
- Disadvantages
 - Hazards to personnel
 - Conventional single animal probes may not be a useful method for mass euthanasia because so much time is required per animal
 - Not useful method for dangerous, intractable animals
 - Aesthetically objectionable because of violent extension and stiffening of the limbs, head, and neck
 - May not result in death in small animals less than 5 kg because ventricular fibrillation and circulatory collapse do not always persist after cessation of current flow
- Recommendations
 - Require special skills and equipment that will insure passage of sufficient current through the brain to induce loss of consciousness and cardiac fibrillation
 - The method is conditionally acceptable if the aforementioned requirements are met
 - Its disadvantages far outweigh its advantages in most applications

Microwave irradiation

- Heating by microwave irradiation is used primarily by neurobiologist to fix brain metabolites *in vivo* while maintaining anatomic integrity of the brain
- Advantages
 - Loss of consciousness is achieved in less than 100 ms, and death in less than one second
 - The most effective method to fix brain tissue *in vivo*.
- Disadvantages
 - Instruments are expensive
 - Only animals the size of mice and rats can be euthanized with commercial instruments that are currently available
- Recommendations
 - Humane method for euthanizing small laboratory rodents if instruments that induce rapid loss of consciousness are used
 - Only instruments that are designed for this use and have appropriate power and microwave distribution can be used
 - Microwave ovens designed for domestic and institutional kitchens are absolutely unacceptable for euthanasia

Adjunctive methods

- Exsanguination
 - Can be used to ensure death subsequent to stunning or in otherwise unconscious animals because anxiety is associated with extreme hypovolemia
 - must not be used as a sole means of euthanasia
 - animals may be exsanguinated to obtain blood product but only when they are sedated, stunned, or anesthetized
- Stunning
 - Animals may be stunned by a blow to the head, by use of nonpenetrating captive bolt, or by use of electric current
 - Must be followed immediately by a method that ensures death
 - With stunning evaluation of unconsciousness is difficult but loss of menace, blinking, pupillary dilation, and the loss of coordinated movement can be useful
 - Specific changes in the EEG and a loss of visually evoked responses are also thought to indicate loss of consciousness
- Pithing
 - Generally used as an adjunctive procedure to ensure death in an animal that has been rendered unconscious by other means.
 - In some species such as frogs with anatomic features that facilitate easy access to the CNS pithing may be used as a sole means of euthanasia, but anesthetic overdose is a more suitable method

Post Euthanasia - Indicators of death

- Check there is no heart beat
- Check there is no respiratory activity
- Check for signs of muscular rigidity (rigor mortis)
- Check for pupillary reflex of the eye
- Lack of blood pressure reading (particularly indicative by invasive monitoring)
- Change of skin configuration
- Involuntary urination or defecation