

Overall, it is apparent that we need to reevaluate the current structure of our profession in order to deal effectively with the inertia that will lead to a manpower surplus. It is obvious that no single solution will emerge; instead we need to develop a multi-faceted approach to the problem. To pursue any of the restrictive proposals presented here or elsewhere will require major alterations in an institutional and bureaucratic framework that is structured for growth instead of steady

state. To pursue expansive proposals will require the creativeness and ingenuity of individuals and institutions as well as aggressive public relations and education to demonstrate the quality and the extent of our training in medicine and other biological sciences. We are challenged with a complex problem, but inherent in this challenge is the opportunity to advance and improve our profession.

Methods of Euthanasia

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The killing of animals is perhaps the most consistent task faced by veterinarians in all facets of the profession. In private or institutionalized practice, in almost any area of active research, in meat inspection, and in pathology and diagnostic services, one common shared activity is the actual or supervisory killing of animals. The motivations, methods, and considerations are myriad, but the process of inflicting death on a variety of living creatures is an inseparable, undeniable part of the veterinary profession.

Euthanasia is by definition³ the act of inducing death, without pain, to the animal being killed. Various dictionaries add easy, quiet, and lacking anxiety to the primary criterion of a euthanasia, which is painlessness. Animals killed by and for veterinarians are variously described in the veterinary and human medical literature as being sacrificed, destroyed, terminated, slaughtered or even harvested. In companion animal practice, pets may be put down, put to sleep, or put out of their misery. Perhaps this rather vast array of terms to describe a single process may be an indication of the

reluctance of people to deal with the situation directly, completely, and honestly. The authors of this paper believe it should be repugnant for any veterinarian to condone the destruction of any animal by a method that cannot be considered humane. Because the unconscious animal cannot perceive pain, a humane death may be defined as one wherein the animal is rendered unconscious (and thus insensitive to pain) as rapidly as possible, with the least possible amount of fear and anxiety.

The task faced by veterinarians almost daily throughout their professional lives is the matter of choosing and applying a suitable method of killing a patient which has been appointed to die, usually because of a hopeless or incurable disease condition, or in order to diagnose a disease so that other animals in similar circumstances can be successfully treated. The handling of each case presented for euthanasia is made unique by the individual animal and human personalities involved.

There are many methods which may be employed to reach the same end result. The ideal method should satisfy several criteria:

1. It should be painless.
2. It should not cause undue anxiety, alarm, fear, behavior, struggling, vocal-

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ization, muscle spasms, or clinical signs of autonomic activation.

3. It should cause unconsciousness instantaneously and death within minutes.
4. It should always cause death when properly used.
5. It should be safe for the properly trained person to use.
6. It should be easy for the properly trained person to use.
7. It should not be a drug attractive for abuse in human beings.
8. It should be aesthetically unobjectionable. This criterion depends on who the observers are.
9. It should be practical to use for the particular type of animal to be killed.
10. It should be economical.
11. It should not create a problem of sanitation or environmental contamination.
12. It should not cause tissue changes which will alter postmortem examination or chemical tests.

It is very unlikely that any agent, either chemical or physical, will ever satisfy all of these criteria for any single euthanasia. The decision of which of the many available methods to employ must be based on as many of these ideals as possible, with the veterinarian as well informed as possible on the characteristics of the agents from which he selects.

The choice of agents is complicated by the fact that unconsciousness and death do not coincide and that it may be difficult for an observer to know whether an animal is in distress, or is actually unconscious and is vocalizing or struggling involuntarily and without pain. Objective judgments along these lines can be made by studying the multitude of published research monitoring electroencephalograms, electrocardiograms, electromyograms, pulses, and respirations of animals dying by various means.

For the purposes of this paper, euthanizing agents will be categorized in one of three groups: 1) inhalant, 2) parenteral, or 3) physical.

Inhalant agents which may be used to kill animals include the inhalant anesthetics (ether, chloroform, halothane, methoxyfluorane, enflurane, cyclopropane, and nitrous oxide), as well as nitrogen gas, hydrogen cyanide, carbon dioxide, and carbon monoxide.

The anesthetic gases may be the agents of choice for euthanasia of birds, rodents, cats and small dogs. These agents cause rapid loss of consciousness and death by hypoxia. Chloroform, halothane, methoxyfluorane, enflurane, and nitrous oxide are, under ordinary circumstances, nonflammable and nonexplosive; cyclopropane and ether are both explosive and flammable. Disadvantages of the inhalant anesthetics for euthanasia are: anxiety during induction evoked by irritating vapors and initial excitatory action on the central nervous system, hazard to the person administering the agent, and relatively high cost. Also, contact of the animal with the liquid before it volatilizes should be avoided to prevent undue animal discomfort.

Nitrogen gas may be used effectively for euthanasia of animals over 4 months of age, provided that equipment is properly constructed, maintained, and operated. Research on 360 animals by Fitch *et al*² demonstrated that all subjects became unconscious within one minute with no signs of pain. Some hypoxia-related movement and vocalization occurs in the unconscious animal, which may be a disadvantage when an aesthetic death is important.

Hydrogen cyanide has been used for euthanasia and been found very rapid and reliable. Because it is extremely irritating to the respiratory mucosa, produces violent convulsions prior to death, and represents a considerable safety hazard to personnel, it is not generally recommended for routine euthanasia.^{2,10,13}

Carbon dioxide is odorless, heavier than air, and has a rapid anesthetic effect in concentrations greater than 7.5%. Inhalation of 60% CO₂ will cause loss of consciousness within 45 seconds and stop respiration within 5 minutes. Research by Croft⁴ indicates that animals do not detect the presence of high CO₂ concentrations before its depressant effect occurs. Carbon dioxide is inexpensive, nonexplosive, nonflammable, and minimally hazardous to personnel when properly maintained equipment is used. It does not accumulate in the tissues of food-producing animals or cause changes in cellular architecture.⁶

Carbon monoxide can also produce rapid painless death without alarm to the animal being killed. Because it is undetectable when properly used, people employing CO for

euthanasia must be aware of potential hazards to themselves. Automobile exhaust as a source of carbon monoxide is acceptable only if the exhaust fumes are adequately cooled and filtered and the engine is operating efficiently with a rich fuel-air mixture.

Parenteral pharmacologic agents are the most commonly used euthanatizing methods employed in the Iowa State University teaching hospital and in student laboratory exercises. For tractable, nonvicious animals, these are the agents of choice because of their reliability and rapidity of action. The preferred route of administration is usually intravenous, although in some situations, intraperitoneal or intracardiac injections are more feasible.

Barbituric acid derivatives depress the central nervous system rapidly, producing unconsciousness within seconds,⁸ followed by death due to depression of the respiratory center of the medulla. Advantages are rapidity of action, aesthetic induction when properly administered, and lack of disturbing unconscious behavior prior to death. Disadvantages include discomfort and disturbing induction when intravenous injection is not achieved, and the attractiveness of these agents for human abuse. It is the recommendation of the AVMA Panel on Euthanasia³ that the advantages of the barbituric acid derivatives far outweigh the disadvantages. For nervous or intractable subjects, preinduction use of tranquilizers or sedatives may be considered.

In order to eliminate the disadvantage of using a controlled substance for euthanasia, commercial euthanatizing solutions are available. An example is T-61^a, which is attractive because it eliminates the necessity of locked cabinets and careful record-keeping. Although research indicates that the animal's sensation during induction and death may be markedly similar to those using barbiturates, many observers have been disturbed by the frequency of unaesthetic reactions. If T-61 is injected too rapidly (except in the horse), animals may appear to experience distress and pain prior to unconsciousness.

While the use of the curariform drugs (curare, succinylcholine, pancuronium, glyceryl fenesin, and other neuromuscular blocking agents) appears to produce a very

nonviolent and outwardly aesthetic death, it should be remembered that death is due to paralysis of respiratory muscles followed by hypoxia and suffocation. There is no depressant action on the brain, and consciousness has been shown to remain for 2 to 3 minutes¹³ following paralysis. The use of these drugs alone to kill animals is unacceptable, although in some instances they may be used to immobilize an animal prior to the administration of other agents when restraint itself is a dangerous, painful, or traumatic procedure.

Other parenteral agents include nicotine, magnesium sulfate, chloral hydrate, and the combination of chloral hydrate, magnesium sulfate, and sodium pentobarbital. These will not be discussed here except to state that the latter combination is suggested as a suitable means of euthanatizing large animals.¹²

The final category of euthanatizing methods is the physical agents, which include gunshot, captive bolt, electrocution, microwaves, and cranial disarticulation.

Gunshot and captive bolt are, when properly applied, rapid and effective, killing the animal by direct concussion of the brain. Gunshot is frequently used to kill large animals, especially by practitioners in the field. Tissue changes do not occur except for the obvious ones to the brain itself; this destruction of the brain frequently makes these methods impractical because post-mortem examination of the brain may be desired. The use of microwaves to humanely kill small rodents has been reported¹⁴ and appears promising, although not yet ready for general use.

Decapitation and cervical dislocation are often used to kill lab animals and birds. These methods are effective and acceptable provided that rapid deliberate application of the technique is accomplished to prevent undue animal discomfort.⁵

Another physical means of rendering live animals dead is electrocution. Electricity can kill animals in two ways.^{15,17} A small electric current passing through the body paralyzes muscles of respiration and causes death from asphyxiation. A larger electric current passing through the body causes ventricular fibrillation. Research suggests that consciousness can remain for 12 to 20 seconds after the onset of extremely painful fibrillation.¹

Studies performed between 1950 and 1954 by Croft and Roberts resulted in the conclusion that in order to avoid pain during electrocution, it is essential first to make the animal unconscious by passing a current directly through the brain, from side to side.¹ Only after this has been done, and a classical convulsive pattern, the electroplectic fit, is produced, should the current be passed through the whole body to cause death by ventricular fibrillation and circulatory collapse.² The use of two leads (a single circuit), attached to the lip or ear and to the tail or anus, paralyzes the animal, creates severe muscular pain and suffocation, but does not render the animal immediately unconscious.¹⁷

In 1954, the British Veterinary Association condemned all existing methods of electrocution, because equipment to transcranially stun animals before applying the lethal current did not exist. Special cabinets are now manufactured which satisfy the humane specifications of unconsciousness prior to actual killing. Electrocution can be recommended for euthanasia only when such equipment is employed. This is the opinion of the AVMA Panel on Euthanasia¹³ and the Humane Practices Committee of the Canadian Veterinary Medical Association,¹⁶ as well as that of various humane societies and animal welfare organizations across the globe. The Canadian committee further condemns electrocution by any technique of any animal whose cranial sutures are still cartilaginous, because these sutures interfere with efficient current flow across the brain.

Another physical method used for euthanasia is rapid decompression. This subject has been the center of some controversy and will not be discussed here because its use is not widespread among veterinarians at the present time.

Conclusions:

Euthanasia is a broad and controversial topic, certainly one which cannot be covered comprehensively in a work such as this. Each method has advantages and disadvantages, proponents and opponents. Many available methods have not been mentioned.

Euthanasia should be performed as professionally and compassionately as possible under the individual circumstances of each

case. Roger Hatch, in his chapter on euthanizing agents in a well-known textbook of veterinary pharmacology,⁸ suggests that perhaps we should all hold on to our emotions, sentiment, and empathy for animals, lest we kill them as dispassionately as we sometimes kill each other. His point is well taken.

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