World Society for the Protection of Animals

Methods for the euthanasia of dogs and cats: comparison and recommendations

WSPA
World Society for the Protection of Animals

FOREWORD

This document aims to provide guidance on the euthanasia of dogs and cats by identifying methods considered humane and methods that might compromise animal welfare.

The euthanasia of companion animals is a much debated issue for animal welfare organisations around the world. Opinions are diverse and are often influenced by local situations and cultural backgrounds.

The decision to euthanase an animal is a complex ethical matter involving many factors, and a detailed discussion of the subject is beyond the scope of this document. As an animal welfare organisation, it is our obligation to ensure that when the decision to euthanase is taken the methods used are truly humane and administered by responsible and appropriately trained individuals.

Methods of euthanasia, scientific knowledge and opinions evolve over time; this overview is based on current scientific evidence and will be subject to review.

Author: Louisa Tasker, MSc, BSc (Hons.)
Editor: Companion Animals Unit, World Society for the Protection of Animals

World Society for the Protection of Animals
89 Albert Embankment
London SE1 7TP
T: +44 (0)20 7557 5000
F: + 44 (0)20 7703 0208
E: wspa@wspa-international.org
W: wspa-international.org

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INTRODUCTION

Criteria for euthanasia

The term euthanasia comes from the Greek 'eu' meaning 'good' and 'thanatos' meaning death, literally translated it means 'good death'. There are four primary criteria that ensure death caused by methods of euthanasia is humane (Beaver *et al.*, 2001). The method must:

1 Be painless
2 Achieve rapid unconsciousness followed by death
3 Minimise animal fear and distress
4 Be reliable and irreversible

To meet these criteria, the method should take into account the species, age and health of the animal. In addition the method should be simple to administer, safe for the operator, as aesthetically acceptable to the operator as possible, and preferably require small doses of any chemicals used.

Reasons for euthanasia

A decision to euthanase an animal is a complex ethical matter involving many factors, and a detailed discussion of the subject is beyond the scope of this document. The World Society for the Protection of Animals (WSPA) believes euthanasia is acceptable and necessary when an animal is suffering due to an incurable illness or injury, or when an animal presents a significant risk to human health and safety or the safety of other animals, through disease or aggressive behaviour.

It is advisable for WSPA member societies, which may have cause to euthanase animals in their care, to adopt an agreed euthanasia protocol that clearly outlines the reasons for euthanasia and the acceptable methods.

WSPA does not condone the mass destruction of dogs and cats as a population control measure. Successful control of dog and cat populations requires a coordinated strategy that has been agreed by all stakeholders and includes:

- Legislation with effective enforcement
- Registration coupled with a dependable method of identification for dogs and cats
- Reproduction control
- Measures to reduce the availability of dogs and cats through the control of breeders, pet-shops and other sales outlets
- Education of owners or guardians so that they act as responsible carers for their animals

Even when these components are in place, WSPA reluctantly accepts that there are circumstances when the euthanasia of healthy animals is required, for example in the case of animals that cannot be rehomed, or to avoid overcrowding in shelters that would compromise the welfare of animals being held there.

WSPA firmly believes that in all situations when euthanasia is deemed necessary, the methods adopted should meet all four of the criteria listed at the beginning of this introduction, and hence be truly humane.

Personnel and training

All methods of euthanasia have the potential to be poorly performed if operators are untrained and unsupported. Consequently, it is essential that operators are provided with suitable training, including a period of initial tuition with assessment of proficiency, followed by continuous monitoring of skills and ability, as well as access to emotional support.

The initial period of instruction should, without exception, include training in both the technical aspects of the methods to be used and the recognition of signs of animal distress. Following the instruction, operators should understand the mechanism by which that particular method of euthanasia causes unconsciousness and death. They should also receive direction and practical training in the careful handling required to prevent distress in the animals they will be restraining for euthanasia. It is essential that operators are taught to recognise the species-typical behaviour and physiological responses that indicate an animal is experiencing fear, distress, pain or anxiety, and how to take immediate action to alleviate these states should they be observed.

Signs of pain and distress

The following behaviours or physiological responses may be signs of pain and distress:

Aggression towards humans or redirected towards self or inanimate objects e.g. snapping, biting, growling, scratching
Vocalisation – whining, whimpering, high pitched barking, howling, or growling in dogs, hissing or yowling in cats
Attempting to escape or withdraw from the situation
Struggling
Panting
Hyperventilating
Salivating

Pupils becoming dilated
Pilo-erection (hair standing on end)
Increased heart rate (tachycardia)
Shivering, muscle tremors and spasms; these may also result from reflex skeletal muscular contractions
Immobility or freezing (the animal becomes tense and stops moving, but remains conscious and aware of the situation)
Urination
Defecation
Anal sacs are emptied (foul smelling liquid is evacuated)

Confirmation of death

All operators performing euthanasia should be able to identify when death has occurred. Indicators include:

- **No movement of the chest / No signs of respiration**
  The animal's chest has stopped moving up and down indicating that it has stopped breathing.
  DO NOT rely on this sign alone as the animal's heart may continue to beat for some time after it has stopped breathing

- **No heart beat**
  Check for this with a stethoscope or by palpating the animal's chest wall.

- **No pulse**
  Check for this by palpation over the medial aspect of the animal's hind limb.
  Not always easy to locate in small animals

- **Loss of colour from the mucous membranes in the animal's mouth**
  Mucous membranes become pale and there is no capillary refill if pressure is applied. With time the mucous membrane becomes dry and sticky.
  Capillary refill is frequently still evident for prolonged periods after an animal has died

- **Corneal reflex (blink reflex) is lost**
  The corneal reflex is normally elicited when the eyeball is touched. After death, the animal's eyes remain open and the lids do not move when touched.

- **Glazing of the eyes**
  This occurs rapidly after death. The cornea loses its clear, moist appearance and becomes opaque, dry and wrinkled.

- **Rigor mortis**
  If death cannot be confirmed by a veterinary surgeon, or there is any doubt, operators should wait until rigor mortis has set in before disposing of the animal's carcass.

Carcass disposal

- **No animal should be disposed of until death is verified**

- **Disposal should take into account regulations, disease control and drug residues**
  Once death has been confirmed the animal should be disposed of in accordance with the local and/or national regulations. These rules should be obtained from the local municipality or relevant animal health/ environment departments in advance and all operators should comply with the necessary procedures.

  This is especially important for disease control. Moreover, many of the injectable agents used for euthanasia may leave residues in animal carcasses. These drug residues may pose a threat to other animals in the event that the carcass is eaten and may cause localised contamination upon carcass decomposition.

- **Suspect rabies cases require cautious handling and compliance with reporting regulations**
  Special precautions should be taken when handling the carcass of any animal suspected of carrying rabies, including the use of protective clothing: gloves, overalls, eye goggles and protective shoes.

  The carcass should be sealed in a plastic bag, as the rabies virus can remain active for some time after death. The external surfaces of the carcass can remain infective for several hours after death, and the internal organs can remain infective for several weeks depending upon environmental temperature, so burial is not recommended. National or local regulations may require that the carcass, head or a sample of brain tissue are sent to a public health authority laboratory for testing and surveillance.

Professional and sympathetic conduct

All operators need to show professionalism and respect for animal welfare, for the value of animal life, and for other people involved. The degree of distress that operators and other people experience when euthanasia is performed will be affected by their culture, beliefs and the community in which they live.

Operators should be emotionally supported and trained to develop coping mechanisms to deal with this stress. This is important for many reasons, including the risk that dissatisfied personnel may become careless when handling animals and performing euthanasia. Ensuring that the methods used are humane can also help to reduce the distress experienced by operators and other people.

METHODS FOR THE EUTHANASIA OF DOGS AND CATS

The following pages assess the methods of euthanasia in current use, in terms of the effects on the animal and additional information regarding usage. The methods are divided into the following categories:

RECOMMENDED

This method is considered 'best practice' because it consistently produces a humane death when used as the sole means of euthanasia.

ACCEPTABLE

These methods also produce a humane death when used as the sole means of euthanasia. However, there are practical limitations to their use.

CONDITIONALLY ACCEPTABLE

These methods are acceptable only with caveats, due to the nature of the technique, potential for operator error, or safety hazards to personnel. These methods may not consistently cause death humanely.

NOT ACCEPTABLE

These methods are inhumane and are not considered acceptable for the euthanasia of dogs and cats.

Some methods of euthanasia can be used in combination with pre-euthanasia drugs, and these are discussed after the summary table. A detailed overview of each euthanasia method, giving rationale for their categorisation, is provided on pages 15–21.

RECOMMENDED

Method	Remarks
Intravenous (IV) injection of 20% Pentobarbitone solution *Barbiturate* *Page 15*	• Regarded as '**best practice**' • Rapid acting • Rapid loss of consciousness, followed by cardiac arrest • May be used in combination with a pre-euthanasia drug if required for fearful, fractious or aggressive animals • No distressing side effects • Requires training • Relatively cheap • Not licensed for use in all countries • Cost and availability may vary from country to country • Combinations of high concentrations of barbiturate with a local anaesthetic may also be available and suitable if given intravenously as a euthanasia agent

ACCEPTABLE

Method	Remarks
Intraperitoneal (IP) injection of 20% Pentobarbitone solution *Barbiturate* *Page 15*	• Slow acting • Takes longer to take effect than IV injection: 15–30 minutes (dependent upon the species and size of the animal) • A larger dose may be required than if given intravenously • May be used when collapsed or poor venous access precludes IV injection • May not be suitable for the euthanasia of larger animals • The use of pre-euthanasia drugs may prolong the time until death • May cause irritation to the peritoneum, particularly with concentrations >20% • Can be combined with a local anaesthetic to reduce the risk of irritation • Animal may become distressed when it starts to lose consciousness • May be a practical alternative when IV injection is difficult e.g. for fractious stray or feral cats, neonatal kittens and puppies. It is advisable to return cats to a secure cage after injection as they may become distressed while the drug takes effect
Intravenous (IV) injection of anaesthetic agents, given as an overdose *e.g. Thiopentone or Propofol; Thiobarbiturate or Phenol compound* *Page 16*	• Rapid acting • Rapid loss of consciousness • May be suitable if animals are already anaesthetised for surgery and, on humane grounds, not permitted to regain consciousness • Relatively large volumes or high concentrations required to euthanase animals, potentially making it impractical for routine use depending upon the commercial availability of the preparation • Under-dosing may lead to recovery • May be used in combination with a pre-euthanasia drug if required • Requires training • Cost may preclude routine use

CONDITIONALLY ACCEPTABLE

Method	Remarks
Intracardiac (IC) injection of 20% Pentobarbitone solution *Barbiturate* **Only acceptable if animals are anaesthetised by other means prior to its administration (page 14)** *Page 15*	• Rapid acting • Only suitable in collapsed, unconscious animals, or very young puppies and kittens • May be suitable if animals are already anaesthetised for surgery and, on humane grounds, not permitted to regain consciousness • Intracardiac route may be painful in fully conscious animals • Requires training, skill and knowledge of anatomy to ensure penetration of the heart is successful on the first attempt • Same licensing restrictions apply as with IV injection
Oral (PO) administration of Pentobarbitone *Barbiturate* **Only acceptable for neonatal animals or to sedate animals prior to intravenous injection of 20% pentobarbitone solution** *Page 15*	• Slow acting • Takes longer to take effect than IV injection (over 30 minutes) • May be suitable for neonates (within the first few hours/days of life) as poor venous access precludes IV injection • Not suitable for the euthanasia of larger/older animals • May be used to sedate animals prior to euthanasia with intravenous injection of Pentobarbitone • Liquid form of the drug may be detected by animals in their food and ingestion is avoided • Powdered form may be delivered in gelatine tablets and hidden in food to encourage consumption • Animal may become distressed when it starts to become unconscious • Same licensing restrictions apply as with IV injection
Intravenous (IV) injection of T61 in a controlled manner, after prior sedation *Contains 3 drugs: general anaesthetic, local anaesthetic and curariform-like agent* **Only acceptable if animals are sedated by other means prior to its administration and injection rate is slow (page 13)** *Page 16*	• Rapid acting • Causes death by respiratory collapse due to paralysis of the diaphragm and intercostal muscles, resulting in asphyxia • Requires slow, steady rate of injection • Precise rate of injection is required: its use in fractious animals is problematic • Intense pain may result if the injection is given too quickly, due to muscle paralysis prior to loss of consciousness • It should never be used without prior sedation to permit slow rate of injection • Requires training and skill • No longer available for use in the United States
Intravenous (IV) or intracardiac (IC) injection of potassium chloride (KCl) after general anaesthesia *Concentrated electrolyte solution* **Only acceptable if animals are anaesthetised by other means prior to its administration (page 14)** *Page 16*	• Rapid acting • Causes death by cardiac arrest • It should never be used without prior general anaesthesia to achieve sufficient insensibility and analgesia, to block the painful side effects of this method • Requires training to ensure operator can assess suitability of anaesthetic depth prior to use of KCl • Prior use of narcotic and analgesic mixtures adds significantly to the cost and prolongs the time of the procedure

CONDITIONALLY ACCEPTABLE

Method	Remarks
Intravenous (IV) or intracardiac (IC) injection of magnesium sulphate ($MgSO_4$) after general anaesthesia *Concentrated electrolyte solution* **Only acceptable if animals are anaesthetised by other means prior to its administration (page 14)** *Page 17*	• Rapid acting • Causes death by cardiac arrest • It should never be used without prior general anaesthesia to achieve sufficient insensibility and analgesia, to block the painful side effects • Requires training to ensure operator can assess suitability of anaesthetic depth prior to its use • Large volumes are required for euthanasia • A saturated solution is required but this makes the liquid very viscous and can result in difficulty of administration • Prior use of narcotic and analgesic mixtures adds significantly to the cost and prolongs the time of the procedure
Inhalation of gaseous anaesthetics such as halothane, enflurane, isoflurane and sevoflurane *Volatile inhalation anaesthetics* *Page 17*	• Slow acting • Requires high concentrations to be effective • Only suitable for small animals (weighing <7kg) • May be suitable if animals are already anaesthetised for surgery and, on humane grounds, not permitted to regain consciousness • Difficult to administer to large animals • In un-anaesthetised animals the smell of the volatile agent may be unpleasant, such that they try to avoid it or hold their breath for a short time • In un-anaesthetised animals it may cause respiratory distress as many can act as irritants • Can be harmful to operators: risk of narcosis if exposed to the volatile agent • Expensive • Not routinely recommended as there are better alternatives
Shooting a free bullet to the head *Physical method* *Page 20*	• Rapid acting • Can cause immediate insensibility if done correctly with an accurate shot • Death by physical damage to the central nervous system • Only acceptable in emergency situations where no other acceptable methods are possible because the animal cannot be handled or given pre-euthanasia drugs and it is necessary to alleviate the suffering of an individual • Not for routine use • Requires training • Requires skill and precision • May require a licence: firearm use is likely to be subject to national and local regulations • Dangerous and unpleasant for operator and any other persons present

NOT ACCEPTABLE

Method	Remarks
Intravenous (IV) injection of T61 when used alone *Contains 3 drugs: general anaesthetic, local anaesthetic and curariform-like agent* *Page 16*	• May produce intense pain and causes death by paralysis of muscles leading to asphyxiation prior to loss of consciousness if the injection rate is too quick • Not acceptable when used alone for euthanasia • No longer available for use in United States
Intravenous (IV) injection of potassium chloride (KCl) given alone or only with prior sedation *Concentrated electrolyte solution* *Page 16*	• Cardiotoxic – causes cardiac arrest without rendering the animal unconscious • Produces severe cardiac pain as a result • Sedation provides insufficient analgesia to block painful side effects of euthanasia agent • Not acceptable when used alone for euthanasia
Intravenous (IV) injection of magnesium sulphate ($MgSO_4$) given alone or only with prior sedation *Concentrated electrolyte solution* *Page 17*	• Causes cardiac arrest without rendering the animal unconscious • May cause intense pain and distress • Sedation provides insufficient analgesia to block painful side effects of euthanasia agent • Not acceptable when used alone for euthanasia
Oral (PO) or intravenous (IV) administration of chloral hydrate (CH) *Chemical reagent with sedative/ hypnotic properties* *Page 17*	• Slow acting • Death results from depression of the central nervous system resulting in hypoxia • Results in convulsions, muscular contractions and gasping • Distressing and painful side effects • Large volumes are required to be effective • Not acceptable for euthanasia
Inhalation of nitrogen (N) or nitrogen/argon mixtures *Gases* *Page 18*	• Slow acting • Death due to hypoxia from paralysis of the respiratory centre • Hypoxia may occur before loss of consciousness even at high concentrations, which is distressing for animals • Vocalisation, convulsions and tremors have been observed prior to death • Very young animals (<four months) can take up to 30 minutes to die as they may be resistant to hypoxia • Welfare aspects not entirely known • Requires specially constructed chambers • Requires a pure source of nitrogen/argon such as cylinder gas • Not recommended as better alternatives available
Inhalation of carbon dioxide (CO_2) *Gas* *Page 18*	• Slow acting • Death by asphyxia • Appears to be aversive in most species • Acts as an irritant to the mucous membranes • Animals may experience pain and distress prior to loss of consciousness, associated with breathlessness, from increased concentrations of CO_2 in the blood and acidosis • Young animals (<four months) are particularly resistant to hypoxia and may take longer to die • Requires specially constructed chambers • Requires a pure source of CO_2 such as cylinder gas • Based upon current research to date on humans and other animals there are sufficient welfare concerns to indicate that this method should not be used for euthanasia

NOT ACCEPTABLE

Method	Remarks
Inhalation of carbon monoxide (CO) *Gas* *Page 19*	• Slow acting • Highly variable time taken to lose consciousness and can take up to two minutes at 6% concentration • Death by hypoxia • Vocalisations and agitation observed in dogs and this may occur while they are still conscious • Distressing side effects observed in cats during induction • Animals <4 months of age and sick or injured animals may have some resistance to hypoxia caused by exposure to CO • Requires specially constructed chambers that are diligently maintained and are operated to safeguard animal welfare and human safety • Requires a pure source of CO such as cylinder gas • Potential danger to operators either through repeated exposure of low concentrations when operating the chamber or through accidental exposure to a lethal dose • Sufficient animal welfare and human safety concerns that this method cannot be recommended for euthanasia
Inhalation of carbon monoxide (CO) exhaust fumes from petrol engines *Gas* *Page 19*	• In addition to above these are hot and contain irritant impurities • Not acceptable for euthanasia
Inhalation of nitrous oxide (N_2O) *Gas* *Page 19*	• Slow acting • Death results from hypoxia • Used alone it does not cause anaesthesia • Causes respiratory distress before the animal loses consciousness • Requires large concentrations – must maintain 100% concentration for the duration • Requires specially constructed chambers • Requires a pure source of N_2O such as cylinder gas • Human health hazard if exposure occurs • Not acceptable for euthanasia
Inhalation of Ether *Inhalation agent* *Page 19*	• Slow acting • Causes death by hypoxia • May cause respiratory distress • Irritants to the respiratory system • Requires large concentrations and rapid exposure to be effective • Requires specially constructed chambers • Highly inflammable and may be explosive – dangerous to operators and all other persons present • Not acceptable for euthanasia
Captive bolt *Physical method* *Page 20*	• Rapid acting • Although potentially and theoretically an acceptable method this is not recommended for routine use due to practical difficulties including: • Requires skill and knowledge of anatomical variation in dog breeds e.g. dolichocephalic, brachycephalic, mesaticephalic skull types • Animal's head needs to remain steady to ensure accurate shot (this may be particularly difficult with cats) • The bolt must be placed directly on to the animals skull • Requires the animal to be restrained (this may be particularly difficult with cats) • Requires further procedure (pithing or bleeding) • Risk of transmission of zoonotic disease (e.g. rabies) if exposed to blood/ brain matter • May cause panic in waiting animals • Not recommended for euthanasia as other methods are more practicable and humane

NOT ACCEPTABLE

Method	Remarks
Electrocution *Physical method* *Page 20*	• Although it is theoretically possible to apply a suitable current and voltage across the skull (so that it passes through the animal's brain) by trained personnel using suitable electrodes, it is WSPA's experience that such conditions are never achieved in practice • Whole body exposure to the electric current in an electrocution chamber is not acceptable • Painful and inhumane under practical conditions • Dangerous to personnel • Not acceptable for euthanasia
Decompression *Physical method* *Page 20*	• Slow acting • Death results from hypoxia • Pain and distress results from expanding trapped gases in the body prior to the animal becoming unconscious • Immature animals are tolerant of hypoxia and require longer periods of decompression before respiration ceases • Aesthetically abhorrent as unconscious animals may bloat, bleed, vomit, convulse, urinate and defecate during decompression • Totally unacceptable
Hanging *Physical method* *Page 21*	• Death by asphyxiation from strangulation • Causes fear and distress • Totally unacceptable
Drowning *Physical method* *Page 21*	• Slow acting • Prolonged death by asphyxiation caused by immersion in water • Causes fear and severe stress • Totally unacceptable
Strychnine *Poison: Neuromuscular blocker* *Page 21*	• Slow acting • Prolonged time for the animal to die and this can be highly variable – from minutes to days depending upon the dose ingested • Causes violent and painful muscle contractions resulting in asphyxiation • Extreme danger to personnel • Totally unacceptable
Cyanide *Poison* *Page 21*	• Slow acting • Causes death by hypoxia and cardiac arrest • Results in violent convulsions and causes pain and distress while the animal remains conscious • Extreme danger to personnel • Totally unacceptable

PRE-EUTHANASIA DRUGS

Pre-euthanasia drugs (tranquillisers, sedatives, immobilisers or general anaesthetics) may be required to facilitate safe and humane handling of animals prior to euthanasia, particularly if they are fractious, aggressive or fearful. Moreover, the prior administration of suitable pre-euthanasia drugs may be necessary with some conditionally acceptable euthanasia agents to ensure they are humane.

The majority of these drugs require minimal animal handling during their administration as they are preferably given as a subcutaneous injection (unless contraindicated by the manufacturer), or sometimes as an intramuscular injection or even via oral dosing. The operator then withdraws and waits for the drug to take effect before administering the euthanasia agent. Some pre-euthanasia agents, however, will require intravenous administration. An important point is that the use of these drugs can add significantly to the time taken to perform euthanasia and this should be considered in advance to safeguard animal welfare.

There are several drugs that are commonly used prior to euthanasia. It is essential that operators understand the different effects each of these has on an animal, as their use may not be appropriate or humane as an adjunct to potentially distressing or painful euthanasia methods. Terms such as tranquillisation, sedation, immobilisation and anaesthesia describe the actions of these drugs. These terms are sometimes incorrectly used as if they were interchangeable, their specific meaning and different effects are explained below.

Tranquillisers

These drugs have some effects in decreasing fear and apprehension while the animal remains awake, making it calm when exposed to low level stimuli. However, they have no analgesic effects and the animal is readily aroused by painful stimulation. Often they give a false sense of security to someone handling an animal, which appears calm but may then display enhanced and even violent responses to a strong stimulus such as a loud noise or an approach by a person. This is potentially dangerous to anyone who has to perform euthanasia.

Example of common tranquillising agent:

Acepromazine maleate (ACP) is a common tranquilliser used in animals, and has some depressing effects on the central nervous system. Its principal use is in combination with other opiate drugs as a pre-medication given before anaesthesia. It will not eliminate any pain associated with euthanasia agents, and increasing the dosage above what is recommended will have little further effect over the tranquillising action, hence this drug cannot be recommended for sole use prior to euthanasia with agents that may cause pain. Moreover ACP should not be used alone to calm fearful animals prior to euthanasia with any, even non-painful agent, as it does not alter the animal's perception of the situation, merely its ability to respond.

Sedatives

These drugs depress the activity of the central nervous system, resulting in drowsiness and muscle relaxation so that animals become uncoordinated. If they are given in sufficiently high doses an animal may fall into a sleep-like state. However, they may not render the animal insensible to pain: the animal generally remains conscious but calm. As with tranquillisers, sedated animals can become aroused by strong stimulation such as a painful procedure, making their behaviour unpredictable.

Examples of common sedative agents:

Xylazine (Chanazine, Rompun, Virbaxyl, Xylacare) is a common sedative used with both large animals (equines and livestock) and small (companion) animals. It induces muscle relaxation and also possesses some analgesic properties. If used alone this drug may not be a suitable pre-euthanasia agent for some conditionally acceptable euthanasia methods, as it does not induce sufficient anaesthesia. In addition this drug will cause a drop in blood pressure, rendering subsequent intravenous injection of euthanasia agents more difficult.

Medetomidine (Domitor) can induce sedation but must be given in a sufficiently large dose. Its use also results in muscle relaxation and provides some analgesia. As with Xylazine, if used alone this drug may not be a suitable pre-euthanasia agent for some conditionally acceptable euthanasia methods, as it does not induce sufficient anaesthesia. Also as with Xylazine, this drug will cause a drop in blood pressure, rendering subsequent intravenous injection of euthanasia agents more difficult.

Butorphanol (Torbugesic, Torbutrol) has some analgesic properties. But both its sedative and analgesic effects are dose dependent. However, this drug may not be suitable for sole use with some conditionally acceptable euthanasia methods, as it does not induce sufficient anaesthesia or analgesia. Its use is unlikely to produce the drop in blood pressure caused by Xylazine or Medetomidine.

Immobilisers

These drugs render the animal immobile by inducing paralysis. The animal's body may become rigid and stiff and the animal appears unresponsive to external stimuli

such as sound. However, the animal can still feel pain and therefore the sole use of immobilisers with painful, conditionally acceptable euthanasia agents is not acceptable.

Example of common immobilising agent:

Ketamine (Ketaset, Vetalar) classed as a dissociative anaesthetic, can also be used for restraint. It may induce muscle rigidity when used alone and produces an altered state of consciousness (catatonia: not a loss of consciousness). Unless combined with other drugs such as Medetomidine, Xylazine and/or Butorphanol to produce sufficient analgesia and anaesthesia, it is not acceptable as a sole pre-euthanasia drug for use with euthanasia agents that may cause pain. Injection by intramuscular or subcutaneous routes may be painful and its rate of absorption can be altered.

Anaesthetics

These result in loss of consciousness and provide good analgesia and muscle relaxation, so that surgical procedures can be undertaken.

Examples of common anaesthetic agents:

Tiletamine-Zolazepam (Telazol®, Zoletil®). This drug combination offers good anaesthesia and allows for an intracardiac injection of pentobarbitone or intravenous or intracardiac injection of conditionally acceptable methods of euthanasia when properly administered. This drug combination should be injected intramuscularly.

Thiopentone and Propofol. These drugs will result in sufficient anaesthesia to allow for intracardiac injection of pentobarbitone or intravenous or intracardiac injection of conditionally acceptable methods of euthanasia. However, both of these drugs must be given intravenously and may be unsuitable for use in animals that are difficult to handle or restrain.

Combinations of pre-euthanasia drugs

Combinations of drugs may enhance their suitability as a prelude to euthanasia, especially if they possess different, complementary analgesic and anaesthetic properties (e.g. Ketamine and Butorphanol). Such combinations should be chosen to render the animal insensible to the pain that may result from some conditionally acceptable euthanasia methods. When using a combination of drugs it is vital that a sufficient dose of each drug is used, and that ample time is allowed for them to reach their maximum effect before euthanasia is undertaken. Moreover, animals should be maintained in a quiet and calm environment as external stimulation can prolong the time taken for drugs to take effect. Both of these factors can be affected by an animal's species (dog or cat), age, body size, demeanour and metabolism, so the individual animal's drug requirements must be carefully determined before this course of action.

Oral administration of drugs or combinations of drugs as a prelude to euthanasia has been explored for dogs (Ramsay and Wetzel, 1998) and cats (Wetzel and Ramsay, 1998; Grove and Ramsay, 2000). For dogs a combination of Tiletamine-Zolazepam/Acepromazine or Pentobarbitone used alone consistently induced sedation and lateral recumbency (Ramsay and Wetzel, 1998). However, the time taken to produce profound sedation was prolonged (30–90 minutes) and highly variable between individuals.

In addition, the sole use of Pentobarbitone was associated with struggling to stand and prolonged ataxia during the onset of full sedation. These undesirable effects were not observed for the Tiletamine-Zolazepam/Acepromazine combination and they may be ameliorated if Acepromazine is added to the Pentobarbitone dose (Ramsay and Wetzel, 1998), but this combination was not tested. It is important to note that liquid preparations of the drugs mixed with food were detected and rejected by dogs (Ramsay and Wetzel, 1998). Uptake by dogs was greatly improved when the required dose of powdered preparations was placed in gelatine capsules and hidden in canned (wet) food.

The oral administration of Detomidine/Ketamine combination was successful in sedating cats (Wetzel and Ramsay, 1998; Grove and Ramsay, 2000) in comparison with other drugs tested (Ketamine, Detomidine, and Xylazine/Ketamine, Medetomidine/Ketamine combinations). This particular combination produced reliable sedation within 10–25 minutes of oral dosing (Grove and Ramsay, 2000). However there are several undesirable side effects that may preclude this from routine use. The oral treatment of cats with all combinations tested (Detomidine/Ketamine, Xylazine/Ketamine and Medetomidine/Ketamine) resulted in vomiting and excessive salivation in some cats (Wetzel and Ramsay, 1998; Grove and Ramsay, 2000) and is likely to cause distress to cats during induction prior to loss of consciousness.

Food dosed with these types of drug is unpalatable, hence precluding accurate administration via food. However, the method of dosing used in these tests (squirting the liquid medicants directly into the cats' mouth) is difficult to perform remotely with any accuracy. The handling of fractious or aggressive cats for oral dosing is likely to cause stress to the animals, thus presenting a welfare issue as well as a potential hazard for operators. Furthermore, Detomidine may not be licensed for use in cats and guidelines for off-label use should be followed.

DISCUSSION OF EUTHANASIA METHODS

The following discussion provides greater detail regarding the use and suitability of each method described in the summary table, to explain the reasons for their categorisation. They are arranged by mode of action and their acceptability for euthanasia.

Euthanasia agents are generally classified by their physical characteristics: non-inhalant (injectable) pharmaceutical agents; inhalant agents (gas mixtures); physical methods; and poisons. They work by one of three modes of action (Close *et al.,* 1996; Beaver *et al.,* 2001):

- Hypoxia – death results from reducing the amount of oxygen available to the animal's cells and tissues.
- Direct depression of the nerve cells in the respiratory centres of the brain necessary for maintaining life function, leading to a loss of consciousness followed by death.
- Physical disruption of brain activity through concussion, direct destruction of the brain, or electrical depolarisation of nerve cells, leading to rapid unconsciousness. Death occurs owing to destruction of the areas of the brain that control cardiac and respiratory functions.

Non-inhalant, injectable pharmaceutical agents

Barbiturate, injectable anaesthetic agents, T61, potassium chloride, magnesium sulphate and chloral hydrate

RECOMMENDED

Barbiturates

Barbiturates act by depressing the central nervous system, starting with the cerebral cortex, which causes rapid loss of consciousness progressing to anaesthesia (Beaver *et al.*, 2001). Their efficacy as anaesthetic agents free from distressing side effects is widely recognised. With sufficient dosages (overdose) barbiturates induce respiratory and cardiac arrest by depressing the centres within the central nervous system that control these life-maintaining functions.

For euthanasia of dogs and cats, barbiturates that have been specifically formulated as euthanasia agents are preferred. The intravenous injection of 20% Pentobarbitone solution is regarded as the most humane method of euthanasia for dogs and cats (Reilly, 1993; Close et al., 1997; Beaver et al., 2001; European Food Safety Authority, 2005) (see Annex 2). Dogs and cats are simply 'put to sleep'; there is no audible or other expression of pain. In some individuals a terminal gasp may occur when the animal is unconscious and although this may distress some observers, it is not an expression of pain or discomfort, merely a reflex action. Pentobarbitone is easy to use, relatively cheap and safe for the operator (provided that it is not misused, e.g. deliberately self-injected).

When the restraint necessary for giving an intravenous injection would distress an animal or pose undue risk to the operator then prior sedation or anaesthesia (pages 13–14) or other accepted alternative routes of administration should be employed (Beaver *et al.*, 2001).

In an emergency situation the drug can be injected directly into the peritoneal cavity (intraperitoneal). The time taken for the animal to lose consciousness and die (15–30 minutes) is longer than if the drug is given intravenously (a few seconds). A higher dose of Pentobarbitone is required for intraperitoneal euthanasia (Grier and Schaffer, 1990; Sinclair, 2004) and it can cause irritation to the peritoneum, but this can be avoided if the drug is combined with a local anaesthetic.

There are no published reports on the use of intraperitoneal injection in dogs; nevertheless Sinclair (2004) provides anecdotal accounts that dogs struggle more than cats; repeatedly attempting to right themselves during the induction phase. For this reason intraperitoneal injection may be unsuitable for larger animals.

While most cats, kittens and puppies appear to advance more smoothly to unconsciousness than adult dogs, they should be closely monitored, and confined to a warm, dark, quiet place to facilitate distress-free induction. The combination of Pentobarbitone and Phenytoin (a cardiotoxic anticonvulsant drug) may be unsuitable for intraperitoneal injection, because of concerns over the differential absorption rates of the two compounds (Sinclair, 2004). The effects of Phenytoin on the heart may occur before the Pentobarbitone component has caused unconsciousness (Fakkema, 1999 cited by Sinclair, 2004).

The technique for intrahepatic injection of Pentobarbitone has been reported by Grier and Schaffer (1990). When correctly administered, its action is considerably faster in comparison to injection via the intraperitoneal route, with cardiac standstill being reported within 11–14 minutes. However, performing accurate intrahepatic injection is technically difficult and may cause animals discomfort (Sinclair, 2004). Administration outside of the target

organ (the liver) is associated with excitement, which may also be distressing to the operator (Grier and Schaffer, 1990).

Injection of 20% Pentobarbitone directly into the heart (intracardiac) may be suitable in collapsed, unconscious animals. However, this requires skill and knowledge of anatomy because failure to inject into the correct place will cause pain. It should only be used by experienced technicians in an emergency.

It may be appropriate to administer liquid form of a suitable concentration of Pentobarbitone orally (by mouth) to neonatal puppies and kittens (within the first few hours/days of life) for euthanasia, as intravenous access is difficult. The time taken for effect is longer than if administered intravenously.

It should be noted that the time taken for oral administration of Pentobarbitone to reach its maximum effect is prolonged (30–90 minutes) and highly variable between individuals given the same dose (Ramsay and Wetzel, 1998). In addition to the lengthy induction time, other undesirable side effects may make this method unsuitable for routine use, for instance some dogs may struggle prior to becoming fully sedated (Ramsay and Wetzel, 1998).

Oral administration of Pentobarbitone for euthanasia of juvenile or adult dogs and cats is unsuitable. It may, however, be used to produce sedation or light anaesthesia to precede intravenous injection of Pentobarbitone for the euthanasia of fractious or aggressive animals (Ramsay and Wetzel, 1998; Sinclair, 2004).

Some euthanasia products have been formulated to use barbiturates combined with a local anaesthetic agent or Phenytoin. The pharmacological differences are inconsequential when injected intravenously but such compounds may be more easily obtained in some countries.

WSPA considers the use of intravenous Pentobarbitone for euthanasia of dogs and cats as 'best practice' (Annex 1, Annex 2) and its use is strongly recommended provided that it is legally permissible and operators have been given appropriate training. However, suitable barbiturates are not always available and in these circumstances WSPA urges veterinary authorities, animal welfare organisations and governments to strive to make these drugs legally and easily available to the relevant professionals.

ACCEPTABLE

Other intravenous anaesthetics
Other barbiturate drugs commonly used as anaesthetics, such as Thiopentone and newer agents such as Propofol, will produce painless euthanasia if given intravenously as overdoses (Annex 1). They work in a similar manner to that described above, rapidly inducing unconsciousness and death. However, larger volumes are required for euthanasia (Annex 1) and often this makes their use more cost prohibitive for routine euthanasia than Pentobarbitone. In addition these agents should not be given other than intravenously, as they may cause tissue reactions at the site of injection leading to pain and discomfort. As with Pentobarbitone, they may be subject to restricted licensing practices.

ACCEPTABLE WITH CONDITIONS

T61
T61 is a mixture of three compounds (embutramide, mebezonium iodine, tetracaine hydrochloride), which provide a combination of muscle paralysis (via curarifrom-like mechanisms), local anaesthetic and general anaesthetic actions (Giorgi and Bertini, 2000). The muscle paralysing agent rapidly induces respiratory collapse by paralysing the animals' diaphragm and intercostal muscles. A local anaesthetic acts to reduce (painful) tissue inflammation at the site of the injection, and the general anaesthetic induces loss of consciousness.

The three compounds have different speeds of absorption in the body (Beaver *et al.,* 2001) and there is a risk that if the injection is given too quickly the animal will remain conscious during respiratory collapse, which may produce pain (Giorgi and Bertini, 2000) and distress (Hellebrekers *et al.,* 1990) prior to death. For this reason T61 should be given by a slow and precise rate of intravenous injection (Beaver *et al.,* 2001). This is likely to be difficult with animals that are anxious when being handled or restrained.

T61 should therefore only be used with prior sedation (page 13) to allow for close monitoring of injection rate and to avoid causing pain to the animal. It should never be given other than intravenously (Annex 1), as the onset of action of each of the three constituents can be altered when administered via alternative routes (Beaver *et al.,* 2001). T61 is no longer available for use in the United States.

ACCEPTABLE WITH CONDITIONS

Potassium chloride (KCl)
The potassium ion is cardiotoxic (has a toxic effect on the heart muscle) and rapid injection of potassium chloride (KCl) as a saturated salt solution causes cardiac arrest leading to death if given intravenously or by the intracardiac route of injection. It has no anaesthetic or analgesic properties so if used alone it causes animals intense pain prior to death. Hence KCl is only acceptable as the final stage of euthanasia in animals given prior narcotic or analgesic agents to block its painful side effects (page 14). It is essential that personnel performing this technique are trained and knowledgeable in anaesthetic techniques. They should be competent at assessing anaesthetic depth appropriate for subsequent administration of KCl.

Euthanasia with KCl is only considered to be acceptable if animals are under general anaesthesia, characterised by loss of consciousness, loss of response to unpleasant (including painful) stimuli and an absence of reflex muscle responses (Beaver *et al.,* 2001). KCl can be easily acquired, transported and mixed with water to form an injectable, supersaturated solution (Annex 1) to kill animals. However, the use of suitable pre-euthanasia drugs will significantly increase both the time taken to perform euthanasia and its cost.

ACCEPTABLE WITH CONDITIONS

Magnesium sulphate ($MgSO_4$)

Magnesium sulphate ($MgSO_4$) is a neuromuscular blocking agent. If delivered intravenously as a saturated salt solution it will lead to cardiac and respiratory arrest followed by death (Close *et al.*, 1996). However, it causes muscle paralysis (inducing respiratory arrest) without prior loss of consciousness (Beaver *et al.*, 2001); the animal therefore remains conscious but immobile until the brain succumbs to lack of oxygen (European Food Safety Authority, 2005). Moreover $MgSO_4$ has no analgesic or anaesthetic properties to block the painful side effects and its sole use as an agent for euthanasia is inhumane (Close *et al.*, 1996, 1997; Beaver *et al.*, 2001; European Food Safety Authority, 2005). Dogs have been observed to experience violent muscle spasms and contractions, vocalising, gasping for breath and convulsion seizures prior to death (Avariez and Caday, 1958), indicating that they experience pain and distress. As with using KCl for euthanasia, $MgSO_4$ is only acceptable as the final stage of euthanasia in animals that are anaesthetised (page 14) and hence unconscious and unresponsive to noxious (including painful) stimuli (and their reflex muscle responses can no longer be evoked). Again, this requirement for pre-euthanasia drugs significantly adds to both the time taken to perform euthanasia and to its cost. Furthermore, large volumes of $MgSO_4$ are required (Annex 1) and an effective saturated solution becomes very viscous and difficult to handle for injection.

NOT ACCEPTABLE

Chloral hydrate (CH)

Chloral hydrate (CH) acts slowly to depress the brain centres responsible for controlling respiration and during the time taken to become unconscious animals display muscle spasms, gasp for breath and vocalise; indicating that they are in distress (Carding, 1977; Close *et al.,* 1996). This drug has no anaesthetic or analgesic properties to block the painful and distressing side effects and it is unacceptable for use in dogs and cats. Even with prior use of anaesthetics its slow mode of action and the large volume required for it to be effective make it unacceptable for euthanasia (Carding, 1977; Beaver *et al.,* 2001).

Inhalant agents (gas mixtures)

Anaesthetic gases, nitrogen/argon, carbon dioxide, carbon monoxide, nitrous oxide and ether

General considerations

Inhalation agents used for euthanasia include volatile liquid anaesthetics and gases or gas mixtures that result in hypoxia; delivered at increasing concentrations they displace oxygen in the air breathed by animals (inspired air) thereby lowering the concentration of oxygen reaching the lungs and tissues (Close *et al.*, 1996).

To be effective, inhaled agents must reach a certain (minimum) concentration in the animal's lungs (Beaver *et al.*, 2001). This means they do not induce an immediate loss of consciousness, and death follows at some considerable time later (European Food Safety Authority, 2005). The humane induction of unconsciousness is important, and any inhalation agents used must not be unpleasant for the animal to breathe or produce pain or distress prior to loss of consciousness (Close *et al.*, 1996, 1997; Leach *et al.*, 2004; European Food Safety Authority, 2005). In particular, inhalation agents that produce convulsions prior to unconsciousness are unacceptable for euthanasia and should not be used (Close *et al.*, 1996; Beaver *et al.*, 2001).

Very young animals are particularly resistant to the effects of lowered oxygen concentrations (hypoxia/anoxia) because their haemoglobin (the oxygen-transporting molecule in red blood cells) has a higher affinity for oxygen than that of adults (Pritchett *et al.*, 2005 cited by European Food Safety Authority, 2005); an adaptation to being in the uterus. Young animals, therefore, take longer to die from hypoxia than adults (Close *et al.*, 1996; Beaver *et al.*, 2001).

Inhaled agents may take longer to build up in the lungs and be effective in animals that are ill, injured or old, as these animals may show decreased ventilation (shallow breathing), making agitation more likely before loss of consciousness (Beaver *et al.*, 2001).

In addition to these general considerations for animal welfare, the health and safety of operators is a major concern with some of these methods. Both acute and chronic exposure to these agents can have toxic effects on humans (National Institute for Occupational Safety and Health, 1977).

ACCEPTABLE WITH CONDITIONS

Anaesthetic gases

Halothane, Enflurane, Isoflurane and Sevoflurane are commonly used as anaesthetic agents and can be used for euthanasia if they are given as an overdose (Annex 1) (European Food Safety Authority, 2005). However, these agents differ in the speed at which they induce unconsciousness and they possess varying degrees of pungency, which animals may find unpleasant (Leach *et al.,* 2004; European Food Safety

Authority, 2005). In addition, animals may struggle and become anxious during induction (Beaver *et al.,* 2001) because anaesthetic vapours may be irritating (Leach *et al.,* 2004). They are therefore not generally considered to be suitable as sole agents for euthanasia in larger animals (>7kg). Halothane is preferred because it may be less aversive during induction (Leach *et al.,* 2004) and produces anaesthesia more rapidly than the other agents (Beaver *et al.,* 2001; European Food Safety Authority, 2005).

Inhalation anaesthetic agents are vaporised and delivered into chambers, via a face mask or tube from anaesthetic machines; they are combined with air/oxygen during induction to prevent hypoxia (Close *et al.,* 1996, Beaver *et al.,* 2001). The liquid states of these agents are highly irritant, and animals should only be exposed to vapours. Chambers and anaesthetic machines should be properly designed to ensure that the gas is evenly distributed and that the animal is rapidly exposed to effective concentrations of the agent (Close *et al.,* 1996). It is important to use equipment that is well maintained and to have scavenging units (devices used to reduce the pollution in the air) to prevent personnel being exposed to the anaesthetic agents, as exposure to trace concentrations of anaesthetic gases is recognised as a human health hazard (National Institute for Occupational Safety and Health, 1977).

The large doses required for euthanasia are expensive and tend to make this method cost prohibitive. With the difficulty in administration and human health aspects, this means that although this can be an acceptable method of euthanasia for small dogs and cats there are more suitable methods available (Close *et al.,* 1997; Beaver *et al.,* 2001). The greatest value of anaesthetic gases may be for the euthanasia of small animals (<7kg) where intravenous access is difficult, and to allow for intracardiac injection of other suitable euthanasia agents. In addition, anaesthetic gases may be given as an overdose to animals that are already surgically anesthetised when, on humane grounds, it is not desirable for them to regain consciousness.

NOT ACCEPTABLE

Nitrogen or nitrogen/argon mixtures

Nitrogen and argon are colourless, odourless gases that are inert, non-flammable and non-explosive. Both gases are present in atmospheric air (nitrogen at 78% and argon at <1%). Placing animals in enclosed containers that are pre-filled with nitrogen or argon induces unconsciousness and results in paralysis of the respiratory centres, followed by death (Beaver *et al.,* 2001; European Food Safety Authority, 2005).

There are few studies on nitrogen inhalation for euthanasia of dogs, but these suggest that loss of consciousness is preceded by hypoxemia and hyperventilation (Herrin *et al.,* 1978) which may be distressing to animals (Beaver *et al.,* 2001). Following loss of consciousness, dogs were observed yelping, gasping and convulsing, and some develop muscle tremors (Herrin *et al.,* 1978), occurrences likely to be aesthetically objectionable for human operators (Reilly, 1993; European Food Safety Authority, 2005). Although time to unconsciousness was 1–2 minutes from initial exposure to the gas, the time to death was recorded at 5 minutes (Herrin *et al.,* 1978). Tranquillising dogs with Acepromazine (ACP) prior to exposure with nitrogen gas for euthanasia (in an attempt to ameliorate the possible distressing side effects of hypoxemia) significantly prolongs the time to death (Quine *et al.,* 1988). It is essential that high concentrations of gas are maintained for the duration until death has been confirmed (European Food Safety Authority, 2005), as re-establishing concentration of oxygen at 6% or greater in the chamber will allow immediate recovery (Beaver *et al.,* 2001).

In summary, the suitability and humaneness of this method is not well understood (Beaver *et al.*, 2001; European Food Safety Authority, 2005). Current evidence indicates this method is unacceptable because animals may experience distressing side effects prior to loss of consciousness, and there are more humane alternatives available for the euthanasia of dogs and cats.

NOT ACCEPTABLE

Carbon dioxide (CO_2)

Carbon dioxide (CO_2) is a non-flammable, non-explosive gas, present in air in small concentrations (0.04%); as a separate gas it is heavier than air (Carding, 1977; Beaver *et al.,* 2001). Inhalation of CO_2 above 70% depresses the central nervous system leading to respiratory arrest and death from asphyxia (Carding, 1968). Depending on the concentration, loss of consciousness may occur within 1–2 minutes but actual death may not follow until 5–20 minutes after initial exposure (Carding, 1968). For euthanasia, CO_2 must be delivered at a controlled rate from cylinders into specially constructed chambers (Beaver *et al.,* 2001).

CO_2 is aversive to most species (European Food Safety Authority, 2005). Concerns over the humaneness of CO_2 (European Food Safety Authority, 2005) stem from its association with breathlessness and hyperventilation (Hewett *et al.*, 1993; Raj and Gregory, 1995). At high concentrations, CO_2 dissolves in the moisture of the animal's air ways producing carbonic acid that causes irritation (Ewbank, 1983, Close *et al.*, 1996) and pain in the animal's nose (Beaver *et al.*, 2001). In cats, induction to unconsciousness is accompanied by escape attempts, licking, sneezing and increased movement or agitation (Simonsen *et al.*, 1981); indicating exposure is distressing (Close *et al.*, 1997). Similarly, in dogs rapid exposure to increasing concentrations of CO_2 produced severe struggling and hyperventilation (Carding, 1968).

Studies conducted in rats have concluded that CO_2 when used in concentrations sufficient to induce loss of consciousness are likely to cause considerable suffering

before unconsciousness (Danneman *et al.*, 1997; Leach *et al.*, 2004). The cumulative stress associated with the induction of unconsciousness when using CO_2 is a serious welfare concern (European Food Safety Authority, 2005). WSPA therefore considers this to be an unacceptable method for the euthanasia of dogs and cats.

NOT ACCEPTABLE

Carbon monoxide (CO)

Methods of generating carbon monoxide (CO) gas for euthanasia of animals have included chemical interaction arising from combining sulphuric acid and sodium formate and the use of exhaust fumes produced from idling petrol engines (Carding, 1977). Both of these techniques produce irritants that are likely to result in considerable distress to animals and are therefore detrimental to the welfare of dogs and cats (Carding, 1968, 1977; Close *et al.*, 1996; Beaver *et al.*, 2001), and hence their use is not acceptable. Commercially compressed CO delivered from cylinders into specially constructed chambers has been used for the mass euthanasia of dogs and cats.

CO combines with haemoglobin in the red blood cells, decreasing the oxygen carrying capacity of the animal's blood. As a result, less oxygen is delivered to the tissues and cells (hypoxia), which leads to unconsciousness, followed by death (Chalifoux and Dallaire, 1983). Although the animal becomes unconscious within 1–2 minutes (variable between individuals), death as confirmed by cessation of heartbeat does not occur until 10–20 minutes after initial exposure to CO at concentrations reaching 6% (Moreland, 1974; Chalifoux and Dallaire, 1983; Dallaire and Chalifoux, 1985). Although the welfare aspects of this method have not been well researched, a few studies have reported that prior to loss of consciousness dogs show signs of anxiety, including moaning vocalisations (Carding, 1968; Chalifoux and Dallaire, 1983; Dallaire and Chalifoux, 1985) and signs of agitation (Moreland, 1974; Chalifoux and Dallaire, 1983). Furthermore, there is some concern that the onset of convulsions (Close *et al.*, 1996) and muscular spasms (Moreland, 1974) may precede loss of consciousness (Chalifoux and Dallaire, 1983; Close *et al.*, 1997). Equally distressing behaviours have been observed in cats during the initial phase of euthanasia using this method (Simonsen *et al.*, 1981).

Use of the tranquiliser ACP prior to euthanasia with CO significantly reduced some of the behavioural and physiological responses of dogs, but sufficient time must be allowed for ACP to reach its maximum effect before exposure to CO (Dallaire and Chalifoux, 1985).

In addition to the risks for animal welfare, CO is extremely hazardous for humans because it is highly toxic and difficult to detect. Even chronic low level exposure is considered a human health hazard and is associated with cardiovascular disease (Beaver *et al.*, 2001).

There are several practical limitations associated with this method of euthanasia. Firstly, the construction, diligent maintenance and careful operation of special chambers are essential to reduce the risk to human and animal welfare; and these are likely to be costly. Secondly, use of CO to euthanase certain groups of animals is considered unacceptable (Humane Society of the United States, undated). In particular, animals under four months old (resistant to hypoxia); those with impaired breathing and or low blood pressure (due to systemic disease, injury or old age) will take longer to succumb, causing additional distress prior to death. Use of CO inhalation to euthanase obviously pregnant animals is also discouraged as the unborn young will not be exposed to the gas and will die slowly as a result of suffocation, due to death of the mother (Humane Society of the United States, undated). Moreover, unconscious dogs urinate, defecate and regurgitate (Moreland, 1974) making this aesthetically objectionable for operators and requiring chambers to be thoroughly cleaned, adding to the time of use.

Although considered a conditionally acceptable method of euthanasia by the American Veterinary Medicine Association (Beaver *et al.*, 2001) and the Humane Society of the United States for some dogs and cats, the many limitations of CO may make this method less practical, considerably slower and more expensive than lethal injection (Humane Society of the United States, undated). There is also concern over the distressing side effects of exposure to CO (European Food Safety Authority, 2005) while the animal is conscious (Stafford, 2006) and over the significant danger to operators. For these reasons WSPA considers this to be an unacceptable method for the euthanasia of dogs and cats.

NOT ACCEPTABLE

Nitrous oxide (N_20)

This gas is no longer considered appropriate as a sole anaesthetic agent as it does not induce anaesthesia in animals even at 100% concentrations (Beaver *et al.*, 2001). If N_20 is used on its own it produces hypoxemia (low oxygen in the blood) (European Food Safety Authority, 2005) before respiratory or cardiac arrest (Beaver *et al.*, 2001) and as a result animals may become distressed prior to loss of consciousness (Beaver *et al.*, 2001). This method is considered inhumane and not acceptable for euthanasia.

NOT ACCEPTABLE

Ether

This is a highly inflammable volatile liquid, which may be explosive under some circumstances. It must be vaporised by the passage of a gas, normally oxygen, to be used as an anaesthetic. Ether is a relatively dangerous substance to use and causes distress by irritation to the nasal passages and eyes to both the animal and the operator (Close *et al.*, 1996). This agent is not suitable for euthanasia, because of extreme risk to operators and the detrimental effects on animal welfare.

Physical methods

Shooting using a free bullet, penetrating captive bolt, electrocution, decompression, hanging and drowning

General considerations

For several reasons physical methods for the euthanasia of dogs and cats are generally not recommended (Close *et al.,* 1997). Some methods are likely to cause severe pain and suffering to animals and are therefore considered inhumane, and unsuitable for euthanasia. In addition the high risk of equipment failure, malfunction and operator error when used in practice will cause pain and distress to the animals. The only physical method considered conditionally acceptable by WSPA – shooting with a free bullet – could be used as a last resort in an emergency situation when no other methods are possible, but not as routine.

Many of these methods may be aesthetically objectionable for personnel, making them distressing to perform and further increasing the stress that operators may experience. Furthermore, if operators are distressed and dissatisfied themselves, there is an increased likelihood of them becoming careless when handling animals.

ACCEPTABLE WITH CONDITIONS

Shooting using a free bullet

An accurate shot to the animal's head will result in immediate destruction of the brain and loss of consciousness, followed by death (Carding, 1977). However, specialist training and considerable skill is required to ensure that the bullet will penetrate the brain. In addition there is extreme danger to the operators and any bystanders, and a firearm should never be used in enclosed spaces as there is a risk of ricocheting bullets. Moreover, the use of a firearm is likely to be subject to strict local and national regulations. WSPA would only conditionally accept this method for use in an emergency situation, when it is necessary to alleviate the suffering of an individual animal but no acceptable euthanasia methods are possible, because the animal cannot be handled or given pre-euthanasia drugs.

NOT ACCEPTABLE

Captive bolt

Although widely used and accepted as a stunning procedure for the slaughter of large livestock species, this method is generally considered inappropriate for dogs and cats (European Food Safety Authority, 2005). The penetrative captive bolt pistol must be placed in contact with the animal's skull and precise positioning is essential so that the bolt penetrates the correct area of the brain first time. Animals must be adequately restrained so that the head remains steady (Carding, 1977; Dennis *et al.,* 1988; Beaver *et al.,* 2001), which makes this method particularly difficult with fearful and aggressive dogs and cats (Carding, 1977). Furthermore, the conformational differences between the skulls of individuals and breeds of dogs increase the risk of a mis-stun. The principle skull types are dolichocephalic (long, narrow head), brachycephalic (short, wide heads) and mesaticephalic (medium proportions).

Use of a captive bolt may be aesthetically unpleasant to the operator, especially as further measures are necessary (e.g. pithing or exsanguination) to ensure death (Beaver *et al.,* 2001). The bleeding that occurs after penetration of the skull and after further pithing creates a hazard for the operator, due to the risk of coming into contact with blood and brain matter. This risk may be of particular concern in rabies-endemic areas.

As there is a high risk of mis-stunning through inadequate use of the penetrating captive bolt, and hence causing pain and distress, WSPA considers this an unacceptable method for the euthanasia of dogs and cats.

NOT ACCEPTABLE

Electrocution

In theory it is possible to achieve euthanasia by applying an appropriate electric current and voltage in a two-step process: first, spanning the animal's brain to render it unconscious – producing an effective stun; second, applying sufficient current across the heart to produce cardiac fibrillation and death from hypoxia (Beaver *et al.*, 2001). However, it is WSPA's experience that such ideal conditions are never achieved in practice. There are grave concerns over the suitability of the design (Carding, 1977) and maintenance of equipment, which, coupled with lack of training and misuse (Phillips, undated), make this method inhumane. If an animal is not effectively stunned, which is often the case with whole body exposure to electric current in electrocution chambers (Carding, 1977), death results from cardiac fibrillation in a conscious animal, and hence involves excruciating pain and distress. In addition this method may be extremely hazardous to personnel, and is aesthetically objectionable as it causes violent extension and stiffening of the animal's limbs, head and neck (Beaver *et al.*, 2001).

WSPA regards electrocution as an unacceptable method of euthanasia for dogs and cats, as the minimum conditions necessary for it to be humane are often not achieved in practice.

NOT ACCEPTABLE

Decompression

This method requires the use of decompression chambers. In theory the low ambient air pressure in the absence of extra oxygen results in cerebral hypoxia, leading to loss of consciousness followed by death (Carding, 1977). However, expansion of trapped gases in body cavities leads to adverse physical effects, pain and discomfort (Close *et al.*, 1996), and is likely to cause anxiety and stress in animals (Close *et al.*, 1997).

In addition this method may be aesthetically unpleasant for the operator as unconscious animals may bloat, bleed, vomit, convulse, urinate and defecate during decompression (Hatch, 1982).

This method is inhumane and therefore not acceptable for the euthanasia of dogs and cats.

NOT ACCEPTABLE

Hanging
Death results by asphyxiation from constriction of the trachea after strangulation, causing the animals fear and distress. This method is inhumane and its use is condemned by WSPA.

NOT ACCEPTABLE

Drowning
Prolonged death by asphyxiation after immersion in water (drowning) causes animals fear and severe stress (Close *et al.*, 1996). This method is inhumane and its use is condemned by WSPA.

Poisons

Strychnine and cyanide

General considerations

These agents cause excruciating pain and distress to animals.

NOT ACCEPTABLE

Strychnine
Strychnine acts on the nervous system resulting in painful muscle contractions and violent convulsions. The animal remains conscious and experiences extreme pain and distress before it dies as a result of suffocation (Lumb, 1985; Close *et al.,* 1996; Beaver *et al.,* 2001). This is an unacceptable agent for euthanasia as its mode of action is inhumane.

NOT ACCEPTABLE

Cyanide
Cyanide blocks oxygen uptake, leading to respiratory collapse. It is accompanied by violent and painful convulsions prior to the onset of unconsciousness and death (Hatch, 1982). In addition, the use of cyanide represents an extreme danger to people as they are equally susceptible to its toxicity. The use of cyanide is inhumane and should never be a method of euthanasia.

The World Society for the Protection of Animals firmly believes that in all situations when euthanasia is deemed necessary the methods adopted should be truly humane. They should achieve rapid, painless death and minimise fear and distress to animals. Our goal is for all countries to adopt the humane methods endorsed by WSPA, and for this document to be used to encourage authorities to make the recommended drugs available.

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ANNEX 1: Dosages and routes of administration of agents for euthanasia of dogs and cats

The information is from those organisations using drugs for euthanasia in the field. The effects of many of these agents are dose dependent. It is therefore essential that an accurate estimate of the animal's weight is obtained prior to euthanasia. In addition the effects of these drugs may be highly variable and dependent upon the individual animal's physical characteristics and circumstances. All manufacturers' instructions should be consulted and adhered to.

Euthanasia agent	Route of administration	Dosage	Remarks	Use of pre-euthanasia drugs indicated?
Pentobarbitone solution Injectable solutions suitable for euthanasia (20%: 200mg/ml)	Intravenous (IV)	150mg/kg for both dogs and cats	Best practice Carcass disposal – recommend incineration	Not unless the animal is fractious
	Intraperitoneal (IP)	Proposed dosage schedule is 2–3 x recommended dose for IV administration when preparations containing concentrations of 390 mg/ml of Pentobarbitone are used (Sinclair, 2004: p 397.) 120–200 mg/kg as necessary (Bishop, 2005:p 291)	Can be an irritant if given by this route Takes longer to take effect than via IV route: 15–30 minutes Carcass disposal – recommend incineration	Yes, ideally unless the animal is unconscious, collapsed
	Intracardiac (IC)	150mg/kg for both dogs and cats	Can be painful if attempted in fully conscious animals Carcass disposal – recommend incineration	Yes, this route of administration is only suitable for unconscious, collapsed animals
	Oral administration (PO)	Dose for neonatal kittens and puppies: despite discussion with animal welfare groups we have been unable to provide suitable guidance on an acceptable dose for oral administration to neonates at this time. Dose for sedation of dogs: 63mg/kg (Ramsay and Wetzel, 1998)	Takes longer to take effect than via IV route Powdered preparation delivered in gelatine capsules can be hidden in food and is less likely to be detected by dogs than mixing the liquid form with food. Highly variable time to take effect even in dogs given the same dose. Prolonged time to take effect: 30–90 minutes.	No
Anaesthetic agents given as an overdose. *Thiopentone* *Proprofol*	Intravenous (IV)	Given to effect	Effective dose is highly variable, dependent upon the animal's age, physical status and use of pre-euthanasia drugs This method is time consuming and costly in comparison to other methods Carcass disposal – recommend incineration	Not unless the animal is fractious, as these agents should be given intravenously

Euthanasia agent	Route of administration	Dosage	Remarks	Use of pre-euthanasia drugs indicated?
T61 (embutramide, mebezonium iodine, tetracaine hydrochloride) after sedation	Intravenous (IV)	Dogs and cats: 0.3ml/kg	Slow, steady rate of injection required Commercially available as a pre-prepared euthanasia solution accept in the USA Carcass disposal – recommend incineration	Yes, should be sedated to ensure slow injection rate
Potassium chloride (KCl) after anaesthesia	Intravenous (IV) or intracardiac (IC)	One proposed dosage schedule is 100g of KCl dissolved in 1 litre of water; 20–30ml of solution sufficient for euthanasia of dogs weighing 15–20kg 1–2 mmol/kg of body weight will cause cardiac arrest (Beaver *et al.,* 2001)	Often available commercially as a powder which is made into an injectable solution by dissolving in water Carcass disposal – recommend incineration	Yes, must be anaesthetised
Magnesium sulphate ($MgSO_4$) after anaesthesia	Intravenous (IV) or intracardiac (IC)	Saturated solution of $MgSO_4$. One proposed dosage schedule is: 83% solution of $MgSO_4$ dissolved in boiling water: Dosage varies little if given by IV or IC route of administration (Avariez and Caday, 1958). But highly variable dose for individuals; one suggested published effective dose: 20–38 ml for a 15 kg dog (Avariez and Caday, 1958). 80mg/kg dose (Close *et al.,* 1996) Saturated aqueous solution 1g/ml at a dose of 2.5–4.0 mg/kg (Carding, 1977)	Often available commercially as a powder, which is made into an injectable solution by dissolving in water Saturated solution becomes very viscous Large volumes required to achieve euthanasia Carcass disposal – recommend incineration	Yes, must be anaesthetised
Gaseous anaesthetics e.g. Halothane, Enflurane, Isoflurane, Sevoflurane, Desflurane and Methoxyflurane	Inhalation	Given to effect Delivered in a carrier gas (usually oxygen) at the minimum alveolar concentration (MAC)	Only suitable for small animals or animals already anaesthetised for surgery Requires an anaesthetic chamber or can be delivered via breathing systems and masks applied to the face Human health hazard if inhaled Carcass disposal – recommend incineration	Not suitable for use in larger animals unless already anaesthetised for surgery and, on humane grounds, they are not permitted to regain consciousness

ANNEX 2: Guidelines on the intravenous injection of Pentobarbitone for the euthanasia of dogs and cats

Introduction

The World Society for the Protection of Animals strongly recommends the use of Pentobarbitone (also sometimes called Pentobarbitone sodium or sodium pentobarbital); a barbiturate specifically formulated for euthanasia. The intravenous (IV) injection of Pentobarbitone 20% solution is regarded as the most humane method of euthanasia for dogs and cats. The method of intravenous injection for dogs and cats can be mastered easily with training. In most cases animals show little or no resistance, provided that they are handled considerately and that they are used to close human contact. In certain countries euthanasia by intravenous injection may only be performed by a veterinarian or by operators working under veterinary supervision.

1. Personnel

Trained, competent and considerate personnel are essential for the humane handling of animals for euthanasia.

A minimum of two people are required for intravenous injection: one person should be able to restrain the animal safely and humanely (referred to hereafter as 'the assistant'), while the second accurately delivers the intravenous injection for euthanasia (referred to hereafter as the operator).

2. Preparation

Appropriate preparation must be made for smooth induction, and to ensure safe and humane handling of animals for euthanasia. In the first instance, personnel should ensure that all materials are available to hand and the environment is suitable, as follows.

3. The environment

A quiet room away from other animals is required in order to avoid dogs and cats becoming excited before the procedure, which would make them difficult to handle, requiring additional restraint.

An examination table approximately 90cm in height, with a non-slip surface, facilitates handling and allows for accurate injection.

Good lighting of the area is essential to enable the operator to see the site of the injection (usually the cephalic vein on the animal's foreleg); therefore facilitating precise delivery of the injection.

4. Special precautions should be taken for suspect rabid animals

Extreme care should be taken when handling and euthanasing animals suspected of having rabies. Special precautions include protective clothing for personnel, and specialist capture and restraint equipment to prevent handlers being bitten and to minimise human contact with animal body fluids. To facilitate safe handling of these animals, sufficient sedation (pages 13–14) should be used prior to injection with the euthanasia agent.

5. Assessment of the animal's temperament and ease of handling

Animals that are not used to being handled by humans may experience fear when placed in novel surroundings, which may result in them showing defensive or avoidance behaviour. Any animals that are likely to be fractious or difficult to handle may pose a risk to personnel through aggressive behaviour. In these instances it is both more humane and safer for these animals to be sedated prior to euthanasia with sufficient time being allowed for the sedative to take maximum effect before euthanasia is undertaken.

Some nervous and aggressive dogs may require muzzling to avoid danger to handlers. If no muzzle is available, a bandage tied around the dog's nose and then behind the head (also known as a tape muzzle) can work in the short term.

Feral cats require special consideration as they are generally extremely fearful of humans. This presents both a welfare concern for the cat and a safety concern for the handlers, as the cat's defensive-aggressive behaviour can inflict injury. The most satisfactory method of capturing a feral cat is to use a cat trap with a squeeze back facility (Figure 1). The captured cat is then pressed against the mesh on the side of the cage so that an injection of a pre-euthanasia agent (pages 13–14) can be given. Once suitably sedated/immobilised the cat can be handled safely.

6. Materials

The following materials are required for intravenous injection:

Syringes

- Disposable syringes with eccentric (i.e. off-centre) nozzles.
- For cats, a syringe size of 2ml is recommended.
- For dogs, syringe sizes of 5, 10 and 20ml will be suitable for most weights.

Disposable needles

- Needle diameter is measured by the 'gauge': the larger the gauge the finer the needle.
- Needles are usually supplied in different coloured containers according to gauge for easy identification. The size of the needle depends upon the size of the animal and the substance to be injected. For an

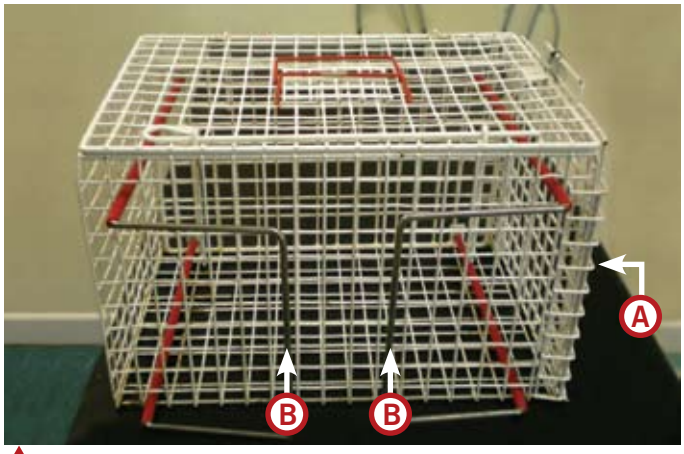

Figure 1.

Photograph of a squeeze-back cage for use with feral cats.

A – Front door to the cage. Once lifted open the cat can be enticed to enter from a cat trap
B – The external 'arms' are moved towards the assistant and the rear wall of the cage pushes the cat flat against the facing wall in the squeeze-back mechanism.

Figure 2.

Photograph showing a dog restrained for intravenous injection. The assistant stands to left of the dog, and her right thumb is used to raise the cephalic vein to enable the operator to insert the needle. Her left arm restrains the dog under the chin.

intravenous injection of Pentobarbitone the following are recommended: Cats: needle of 22–24 gauge and length 0.75 inches (2cm), Dogs: needle of 18–22 gauge and length 1 inch (2.5 cm) is convenient for most size of dog.

Cannulae
If permanent plastic cannulae are available for use they are preferable as they minimise the risk that the needle may slip during the procedure resulting in some or all of the drug not being delivered directly into the vein (see section 7e). The technique for inserting a plastic cannula is similar to that for giving an intravenous injection, but may take a little more training and practice; insertion is especially difficult in smaller dogs and cats.

Euthanasia agent
Injection of Pentobarbitone, 20% solution is considered as 'best practice'; however some euthanasia products have been combined with a local anaesthetic agent or Phenytoin. The pharmacological differences are inconsequential but such compounds may be more easily obtained in some countries.

Dose rate
Where possible the animal should be weighed. If this is not possible, experienced personnel may be able to estimate the animal's weight with sufficient accuracy. The dose of Pentobarbitone should be determined according to the manufacturer's instructions.

7. Method

(a) Filling the syringe
A new, disposable needle should be attached to the nozzle of a new, disposable syringe, and then inserted into the bottle containing Pentobarbitone for filling. To prevent a vacuum forming in the bottle, resulting in difficulty with subsequent withdrawal of fluid, it is advisable first to inject into the bottle an amount of air equal to the volume of liquid to be withdrawn. Fill the syringe with the correct dose, calculated according to the manufacturer's instructions for the animal's weight. Remove the needle and syringe from the bottle and replace the cap on the needle for safety.

(b) Handling and restraint
Dogs
Gently lift the animal on to the examination table. The dog should be facing the operator who will be giving the intravenous injection. Large or fractious dogs may require more than one handler for restraint. If the operator is right handed, the assistant should stand on the animals left. Where possible the animal should be in the sitting or lying position. The assistants' arm passes over the back of the and the other arm holds the animal under the chin (Figure 2).

Cats
The cat should be gently placed onto the examination table, facing the operator for intravenous injection. The assistant should hold the cat against their body, making the cat feel secure.

The animal's head should be held under its chin with one of the assistant's hands, while the other hand raises the cephalic vein (Figure 3). The cat's foreleg should be pushed forward at the elbow, and the thumb and forefinger used to apply gentle tourniquet pressure, as described for dogs in Figure 4.

(c) Site of injection
The cephalic vein in the animal's foreleg is the most convenient site for intravenous injection. When the animal is held correctly the cephalic vein is visible on top of the foreleg (Figure 4). Once the animal has been suitably restrained, it may be necessary to aid visualisation of the vein, particularly in cats and small dogs, to clip a small amount of hair on the foreleg where the injection is to be given.

(d) Preparation for the injection
The assistant's thumb and forefinger of the left hand is used to create a tourniquet effect at the 'crook' of the elbow and inflate or 'raise' the cephalic vein. Mild pressure is applied: using the thumb with a slight outward rotation the cephalic vein becomes clearly visible for injection (Figure 4).

(e) Starting the injection
The cap is removed from the needle and the point of the needle is gently inserted through the skin up and into the vein. The needle is then slid up the vein, parallel to the skin surface. Before injection of Pentobarbitone, it is essential to confirm that the needle is correctly positioned in the vein. In large dogs blood will flow naturally back into the liquid within the syringe. In small dogs and cats it may be necessary to draw the plunger of the syringe back slightly: if positioned correctly blood should flow back into the syringe verifying the needle is indeed in the vein. After the operator has confirmed that the needle is correctly positioned, the assistant releases their thumb pressure so that the intravenous injection can be given.

(f) Ensuring the injection has been delivered
The calculated dose of the agent is injected with care ensuring that the needle remains in the vein and that injection into the surrounding tissues is not occurring. Injection outside of the vein is rare but possible, and causes swelling around the vein. Should this occur the procedure should be stopped, the syringe and needle removed and a new attempt made at a different position on the vein or using the vein on the other foreleg. Extravascular injection of Pentobarbitone may cause pain and irritation to animals and every effort should be taken to ensure precise delivery into the animal's vein.

Normally dogs and cats will become unconscious before the end of the injection and death follows almost immediately with complete freedom from pain or distress when using the recommended dose and with a confident but gentle approach. Death should be confirmed using the indicators stated on page 5. Ideally operators should check for the absence of the heartbeat using a stethoscope, listening to the left side of the chest where the beat is most audible in life or by checking for a pulse, by palpation over the medial aspect of the animal's hind limb. If there's any doubt operators should wait for rigor mortis to set in before disposing of the animal's carcass.

(g) Other sites for intravenous injection
If injection via the cephalic vein is not possible, other sites may be used for intravenous injection, but they may be more difficult and require greater skill.

The saphenous vein can be accessed in either of the hind legs. It is easier to locate in larger dogs than in cats and small dogs. The vein runs down the inside of the hind leg from the animal's body, until it crosses to the outside of the leg above the hock, where it is easiest to reach for intravenous injection. However

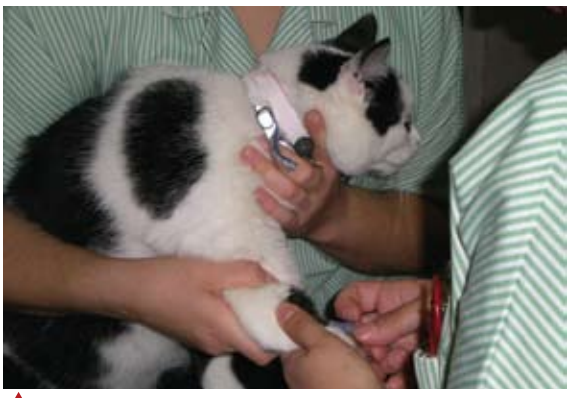

Figure 3.

Typical restraint of a cat for intravenous injection. The cat is held close to the assistant's body, the animal's head is held under the chin with one hand and the assistant uses their other hand to raise the cephalic vein.

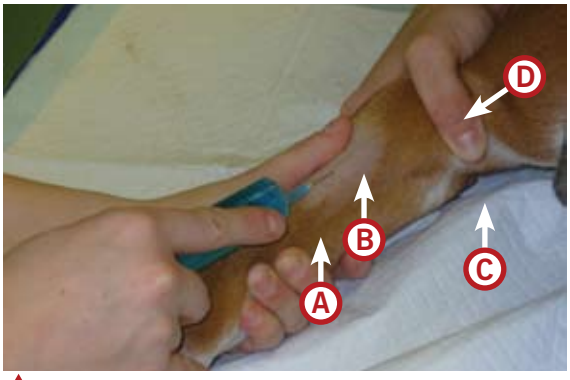

Figure 4.

Insertion of an intravenous cannula into the cephalic vein. The operator is right handed. The assistant stands to the side of the dog, and uses their thumb to raise the cephalic vein, enabling the operator to insert the needle.

A – Shaved area exposing the cephalic vein
B – Raised cephalic vein is clearly visible
C – 'Crook' of the elbow
D – The assistant's thumb and forefinger create a tourniquet effect. The thumb is rotated outward slightly to raise the vein

the saphenous vein is considerably less convenient to use than the cephalic vein, as it is highly mobile when pressure is applied making accurate injection difficult.

The technique for raising the saphenous vein is similar to that used when injecting into the cephalic vein, but it is more awkward for the assistant to achieve as the animal has to be placed on its side (in lateral recumbency) and the hind leg is lifted. The assistants thumb is placed on the outside of the animal's hock joint, while the forefinger encircles the inside of the joint. Thumb pressure is applied with a slight outward rotation to raise the vein for injection. This technique requires additional skill, and should only be attempted by experienced personnel.

8. Additional resources

Humane Society of the United States, Humane Euthanasia by Injection: Training Video Series. Produced by the Humane Society University, www.humanesocietyu.org/resources/euth_video_series.html