Field euthanasia techniques for small ruminants

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Abstract

Goats, sheep, and camelids present unique challenges when selecting a safe, aesthetic, and environmentally responsible method of field euthanasia. Although barbiturate euthanasia products are frequently used in companion settings, access to these drugs is restricted and carcass residues limit viable disposal options. Gunshot, penetrating captive bolt, and adjunctive techniques commonly used in cattle are appropriate for use in small ruminants with modifications to reduce the risk of over-penetration and improve anatomic accuracy. While farm personnel can be trained to safely and effectively use gunshot techniques in adult sheep and goats, safe options for euthanasia of neonatal goats and lambs is severely limited by their small size. Manual blunt force trauma is an unacceptable method in these species; however, non-penetrating captive bolts devices are acceptable for stunning or euthanasia of perinatal kids and lambs. Additionally, carbon dioxide inhalation is an effective and humane technique for goat kids < 3 weeks of age. Intrathecal lidocaine injection is an acceptable method in anesthetized horses and early clinical experience suggests it may be reasonably applied by veterinarians in the field for all ages of small ruminants.

Key words: euthanasia, small ruminant, gunshot, captive bolt, neonatal

Résumé

Les chèvres, les moutons et les camélidés posent des défis particuliers lorsque vient le temps de choisir sur le terrain une méthode d'euthanasie sécuritaire, esthétique et responsable sur le plan environnemental. Bien que des produits barbituriques d'euthanasie sont souvent utilisés dans le contexte des animaux de compagnie, l'accès à ces substances est restreint et les résidus dans la carcasse limitent les options viables d'élimination. Le fusil, le pistolet d'abattage à tige perforante et d'autres techniques auxiliaires souvent utilisées chez les bovins sont appropriées chez les petits ruminants avec des modifications pour réduire le risque de perforation trop profonde et pour améliorer la précision anatomique. Bien que le personnel de la ferme puisse être formé dans l'utilisation sécuritaire et effective des techniques de tir chez les chèvres et les moutons adultes, des options sécuritaires d'euthanasie chez les chevreaux et les agneaux sont très limitées en raison de leur petite taille. Les chocs brutaux manuels ne sont pas acceptables chez ces espèces. Toutefois, des pistolets à tige non-perforante sont acceptables pour étourdir ou euthanasier les chevreaux et les agneaux. De plus, l'inhalation de dioxyde de carbone est une technique efficace et plus humaine pour les jeunes moutons âgés de moins de trois semaines. L'injection intrathécale de lidocaïne est une méthode acceptable pour les chevaux anesthésiés et les premiers essais cliniques suggèrent qu'elle pourrait être utilisée raisonnablement par les vétérinaires sur le terrain pour les petits ruminants de tous âges.

Introduction

Evolving social attitudes among consumer, producer, and veterinarian communities are influencing our approach to animal husbandry, with increased emphasis on animal welfare science, the human-animal bond dynamic, and assurances of humane husbandry practices. Combined with the growth of sheep, goat, and camelid populations in the US, there is an increasing need for timely, aesthetic, and practical on-farm euthanasia options for small ruminants. Better yet, we need options that can be carried out reliably and safely by non-veterinary personnel in order to ensure timely and humane disposition for ill or injured animals as well as promoting use of humane techniques for on-farm harvest and population control. More recently, we are recognizing that the injectable barbiturate drugs commonly used for companion livestock euthanasia pose a significant risk to scavenging wildlife, pets, and raptors. Failure to properly dispose of these carcasses, or for veterinarians to provide adequate client education on appropriate disposal for barbiturate-euthanized carcasses, can result in significant criminal or civil penalties. In addition, local ordinances are increasingly restrictive on incineration, burial, and landfill options for carcass disposal, renderer services are disappearing in many areas (and may refuse carcasses with barbiturate residues), and residues persist through the composting process. As a result, small ruminant veterinarians and owners are employing other euthanasia techniques common to larger livestock species such as gunshot and captive bolt. These techniques can work well on mature animals but present special challenges for smaller dwarf breeds, neonates, and camelids where they are technically more challenging and present increased risk of injury to the operator or bystanders.

Euthanasia, derived from the Greek for "good death", can be defined as a humane termination of life that minimizes or eliminates pain and distress before and during the procedure. From a policy standpoint, euthanasia techniques are considered separately from slaughter or depopulation

practices although there is some overlap between these categories. From a practical standpoint, we should consider the WHY (humane disposition) and the HOW (humane technique), recognize that species, circumstance, setting, resources, and safety will affect our approach, and realize that in extremis, our ability to end suffering may override typical preferences in technique. The AVMA Panel on Euthanasia (POE) publishes guidelines on acceptable, conditionally acceptable, and unacceptable euthanasia methods for a broad range of animals, including specific guidelines for small ruminants; the 2019 update edition is in progress and addresses several newer techniques and updates relevant to small ruminant practice (Table 1). Evaluation criteria include measures of reliable effectiveness, animal aversion/pain/distress, compatibility with signalment and carcass use, human and environmental safety, emotional impact on personnel and observers, resource requirements, and legal considerations. While these guidelines are intended to assist veterinarians in their professional practice activities and are not legally binding, they outline in depth a well-informed national consensus on preferred protocols for euthanasia. These guidelines also indirectly carry legal weight through their role as the reference document for numerous organizations and welfare audit systems.

Across all species, acceptable euthanasia protocols require initial loss of consciousness or anesthesia followed by irreversible chemical, physical, or hypoxic disruption of brain function. Loss of consciousness may occur as an inherent part of a one-step method, as the first part of a two-step method, or through use of general anesthetics (not sedation) prior to application of the euthanasia technique. Convulsions, reflex struggle, and uncoordinated extremity movement can be observed during Stage 2 anesthesia (loss of consciousness to onset of a regular respiratory pattern) and in decerebrate animals, are NOT an indicator of consciousness or pain, but negatively impact the aesthetics and emotional impact of the chosen technique. In all cases, standing, righting reflexes, spontaneous blinking or menace, and voluntary vocalizations indicate that the initial anesthetic or stun step is inadequate.

Overview of Field Euthanasia Protocols

Adult Small Ruminants

There are a relatively limited number of field-appropriate euthanasia options for mammalian livestock. In general, most adult small ruminants can be euthanized by methods suitable for cattle, though special consideration should be given to dwarf breeds, large-horned rams and bucks, and camelids.

Two methods are acceptable as a single-step euthanasia without additional anesthesia or secondary adjunct intervention: barbiturate overdose and gunshot. Pentobarbital is the most commonly used barbiturate and is administered extralabel in small ruminants at a similar dose to other species (1 mL per 10 lb [4.5 kg] body weight) via intravascular injection in the conscious animal or intra-cardiac injection in the unconscious or anesthetized animal. While this method is preferred for producing a quick, smooth, aesthetic death, it is a Schedule II controlled drug, requires significant technical expertise and animal restraint, and results in problematic carcass residues. Alternatively, gunshot produces instantaneous loss of consciousness and death. Many common calibers of handgun, rifle, or shotgun are appropriate for use in conventional adult small ruminants and this is typically the preferred method employed by non-veterinarians on the farm. Disadvantages include human safety risks, legal restrictions, and potential destruction of diagnostic tissues and/or human exposure to infective CNS materials. Specific discussion of firearm and ammunition selection and anatomical landmarks will be addressed later in this proceedings. Although electrocution can be used in a one-step head-to-body technique with small ruminants, the necessary specialized equipment is typically not available for field procedures and use of 120V current is unacceptable.

Ambulatory veterinary practitioners most commonly perform two-step protocols using a penetrating captive bolt to stun an alert patient, followed by an adjunct method (intravenous potassium or magnesium salts, exsanguination, pithing, or 1-2 additional captive bolt stun events) to create terminal cerebral hypoxia or physical disruption of the cortex and brainstem. Captive bolt procedures are safer than gunshot euthanasia and are subject to fewer legal restrictions than firearms. However, some devices are more expensive than many adequate firearms and are less likely to be in the professional inventory of a typical equine or small animal practitioner engaged in small ruminant practice. Alternatively, general anesthesia (typically any of the injectable ketamine-based protocols) can be administered to induce anesthesia and then followed by any of the adjunct methods mentioned above.

Neonatal Small Ruminants

The challenge with neonatal small ruminant euthanasia is two-fold. First, the dairy sectors annually produce a buck/ram crop that nearly matches the lactating herd for size with limited options for diversion into alternate production streams. Secondly, there is a lack of acceptable euthanasia options that can be performed by the producer. Due to their small calvarium and body, gunshot and captive bolt protocols are risky; it can be difficult to consistently hit the brain (though the concussive effect will most likely be adequate), almost impossible to restrain the patient without risk to the operator or assistant, and over-penetration is a near certainty. Unlike swine, manual blunt force trauma does not consistently produce adequate trauma to ensure loss of consciousness and death; "swinging" or hitting the patient is unacceptable. However, some non-penetrating captive bolt devices are acceptable for euthanasia in perinatal (<48 hour) kids and lambs; these non-penetrating bolts can be used to stun in a two-step process in older animals. Furthermore,

Table 1.

Agent (CLASSIFICATION) Process	Production Class	MOA	Pros	Cons	Considerations
Pentobarbital (ACCEPTABLE) Single step	All	CNS depression: progressive starting with the cerebral cortex	Quick Aesthetic FDA-extralabel	Controlled drug Carcass residues Restraint Technical skill	IV or IP; other routes (IC, IH, IR) require anesthesia first ~1 mL /10 lb
Gunshot (WITH CONDITIONS) Single step	All* Caution in very small patients	Physical: trauma to cerebral hemisphere and brainstem	Carcass safety Reduced stress Instantaneous Trained lay technicians	Aesthetics Operator safety Tissues Cost and maintenance Legal considerations	Goal is penetration and destruction of brain tissue without exit wound Handgun: .38 Special, .357 Magnum, 9 mm Rifle: .22LR Shotgun: 28-12g
Captive Bolt, penetrating (WITH CONDITIONS) Two-step	All* Caution in very small patients	Physical: concussion & trauma to cerebral hemisphere and brainstem	Carcass safety Safer than gunshot Trained lay technicians	Aesthetics Tissues Cost and maintenance Restraint	Requires an adjunctive second step (e.g. IV salts, exsanguination, pithing) Second/third shot creates additional trauma to respiratory and cardiac neural centers
Captive Bolt, non-penetrating (WITH CONDITIONS) Single step	Neonates	Physical: concussion (trauma*) to cerebral hemisphere and brainstem	Carcass safety Trained lay technicians	Cost and maintenance Restraint	Neonates <48 hours Stun effect in older animals, needs adjunct
Salts (KCl or Mg) (ADJUNCTIVE) Second step	All Anesthetized / unconscious	Hypoxia: cardiac fibrillation	Cheap Readily available Carcass safety	Restraint Technical skill	IV or IC 30-60 mL of 130g KCl in 1L Sterile Water Step-2, unconscious, or general anesthesia first
Exsanguination (ADJUNCTIVE) Second step	All Anesthetized / unconscious	Hypoxia: Hypovolemia	Carcass safety	Aesthetics	Step-2, unconscious, or general anesthesia first
Pithing (ADJUNCTIVE) Second step	All* Anesthetized / unconscious	Physical: trauma to cerebral hemisphere and brainstem	Carcass safety	Aesthetics SRM contamination of carcass	Step-2, unconscious, or general anesthesia first Via bullet/captive bolt entry
Intrathecal Lidocaine (WITH CONDITIONS) Second step	All Anesthetized / unconscious	CNS depression: direct neural anesthesia	Carcass safety Economical	Technically challenging	Step-2, unconscious, or general anesthesia first
CO2 Gas (WITH CONDITIONS) Single step	Goat kids < 3 weeks	Hypoxia and respiratory acidosis	Rapid Carcass safety Economical Safe Trained lay technician Single step	Variable response Equipment Slow	Initial CO2 concentration <70%, fill to >70% by 5 minutes, 10 min dwell

*Safety/practicality limitations with neonates and smaller animals

parameters for acceptable CO_2 euthanasia have been published for goat kids < 3 weeks of age that can be adapted for on-farm use. Producers or farm employees can use both of these protocols, though they do involve a significant degree of investment into equipment and maintenance.

Special Considerations for Gunshot and Captive Bolt

Gunshot

When selecting a firearm and ammunition combination for euthanasia, the goal is to balance the need for penetration and tissue destruction with the desire to avoid unsafe over-penetration, ricochet, and fragmentation. The destructive potential (kinetic energy) of a firearm is typically expressed as muzzle velocity. Muzzle velocity is a factor of bullet mass and velocity; the minimal recommendation is 300 foot-pounds of muzzle velocity to euthanize a ruminant up to 400 lb (180 kg) body weight.

Generally, a bigger caliber weapon will shoot a heavier bullet and a longer barrel will increase bullet velocity. Common firearms used for small ruminant euthanasia are larger caliber handguns (.38 Special, .357 Magnum, and 9mm) or the common .22LR rifle; the rifle will be more comfortable to shoot with less recoil. Larger animals with a thicker skull will need a larger degree of muzzle energy than a younger animal with a thinner calvarium; euthanasia at point-blank range will require less muzzle energy than a distance shot. The .22LR rifle is widely used but considered marginal for euthanasia in cattle; when used on rams or bucks it should be at close range (1 to 3 feet; 30.5 to 91.4 cm), with a solid point bullet, and careful attention to the appropriate anatomic aim.

Bullet type will also influence degree of penetration. Both a larger power load (grain) and an increasingly solid bullet will increase penetration. Solid point bullets are the most common choice for small ruminants for the combined characteristics of penetration and moderate expansion, though hollow-points will reduce the risk of over-penetration from a higher muzzle-velocity firearm when used in smaller patients and (except for rams and bucks) are unlikely to under-penetrate if fired with sufficient muzzle energy at close distance.

Shotguns are usually an excellent choice for gunshot euthanasia. A major advantage to shotguns is that when fired at close range they have good penetration and tissue destruction but minimal risk of over-penetration. Mature rams and bucks will have similar requirements as mature cattle (20 to 12 gauge) while 28 or 20 gauge is acceptable for most older kids and adult does and wethers; the .410 is adequate for small kids and lambs. Appropriate range for a shotgun is 3 to 6 ft (0.9 to 1.8 m) and both shot (6 shot or larger) and slugs can be used for euthanasia.

Captive Bolt

Captive bolts are either penetrating or non-penetrating in nature. Common commercial non-penetrating devices proven for use on small ruminants include pneumatic and gunpowder-charge powered models. Gunpowder-charge powered (0.22, 0.25, and 9mm calibers) penetrating captive bolts are commonly used in livestock ambulatory practice and are available in an in-line or pistol-grip configuration. The choice is personal preference – many of the in-line models are less expensive than the pistol-grip products, however the author finds that the pistol-grip devices are more intuitive for most users and trainees. Spring-activated poultry penetrating bolts are not suitable for use with lambs and kids. In addition to the caliber of the charge and rod, which is a fixed attribute of the device, some models allow the user to control depth of penetration by switching out the rods or adjusting the number of dampers used. In the author's experience, users are more likely to leave the bolt configuration set up for cattle and instead select charges with differing levels of powder load. As a result, over-penetration is a risk on very small animals; the operator must ensure that any people or body parts are well away from the direction of fire and that the animal is not resting its head on a hard surface (e.g. concrete). The degree of concussion and brain trauma is dependent on the animal's size, anatomical alignment of the bolt, depth of the rod (rod length and damper number), charge used, and operational maintenance. Captive bolts will not function appropriately if they are inadequately stored and maintained. They should be stored in a secure dry location, cleaned after use, and protected with a firearm cleaner-lubricant-protector. Although a penetrating captive bolt that is set up for cattle often produces sufficient trauma to produce irreversible stun and death, the POE recommends an adjunctive method for routine euthanasia. However, there is new evidence in swine that non-penetrating, short penetrating, medium penetrating, and extended penetrating devices were consistently effective as a single–step euthanasia method in animals up to 440 lb (200 kg) body weight. Furthermore, extended bolt devices are under review for use as a single-step procedure in cattle and would be expected to perform similarly in small ruminants. A correctly stunned animal will immediately collapse, demonstrate tetanic spasms and increasingly frequent hind-limb movement, and have a wide blank fixed stare without eye rotation and with complete absence of corneal and palpebral reflexes.

Safety

Best practices are similar for the firearm and bolt; they include proper storage (secure and unloaded), assuming that the firearm or bolt is loaded until proven otherwise, keeping one's finger off the trigger until ready to fire, practicing good muzzle control, and identifying the target and clearing any down-range risks. Proper PPE (ear and eye protection) should be worn. Hunter safety or basic marksmanship firearms safety training courses are frequently offered at local shooting range or through the local Department of Natural Resources office.

Anatomical Approach

Captive bolts should be placed directly against the patient's head. Pistols and rifles should be shot from a distance of at least 1 to 3 ft (30.5 to 91.4 cm), while shotguns should be 3 to 6 ft (0.9 to 1.8 m) away from the patient. Firearms should be aimed toward the foramen magnum.

Average goat/sheep: a) frontal - intersection of an "X" from the lateral canthus of the eye to the middle of the opposite ear, perpendicular to skull; or b) caudo-dorsal: on dorsal midline at the external occipital protuberance, aiming toward the cranial inter-mandibular space. The latter is the author's preference in horned does and wethers, as it facilitates simultaneous restraint and stunning.

Heavily horned buck or ram: frontal approach aimed toward foramen magnum.

Camelids: frontal – intersection of "X" from the medial canthus of the eye to the middle of the opposite ear, perpendicular to the skull; or b) crown – top of head aimed toward the base of the jaw.

Procedure

Apply adequate restraint or sedation. Identify the anatomic landmarks (the authors like to mark the target). Load the captive bolt or firearm, acquire the target and verify the direction of fire is clear of people and body parts. Switch off the safety, call "Fire" if others are working in the area, and fire the bolt or weapon. Verify the animal is unconscious (no corneal reflex). Administer second stun or adjunct method as required, typically 30 to 60 mL of supersaturated (130g KCl in 1L water) potassium chloride IV. Verify death via cessation of heartbeat and all respiratory effort over a 3 to 5 minute period.

Emerging Options

A recently described intrathecal lidocaine technique (60 mL of 2% lidocaine) in anesthetized horses appears to be a feasible low-residue option for small ruminants and camelids. Limited data in small ruminants is available at this time, but clinical experience with size-adjusted doses (~0.1 mL 2% lidocaine per 2.2 lb [1 kg] body weight) is consistent with observations in the equid that this technique can produce a rapid and aesthetically smooth euthanasia. Furthermore, this protocol is technically feasible for a trained veterinarian across a wide range of ages and sizes of sheep, goats, and camelids.

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