

New and Upcoming Euthanasia Techniques

Several techniques have been utilized to offer alternative forms of euthanasia, specifically in piglets and nursery-age animals. These techniques include: carbon dioxide inhalation, carbon monoxide inhalation, alternative gas methods (to be described subsequently), mixed gas inhalation (either CO or CO₂ with an inhalational anesthetic), electrocution, low atmospheric pressure stunning (LAPS), non-penetrating captive bolt gun, and electromagnetic energy euthanasia. A brief, comprehensive synopsis of each technique follows including the pros, cons, and drawbacks to each technique.

- 1. Carbon dioxide inhalation:** In this technique, piglets are placed in a chamber with sealable lid and an inlet for CO₂ gas. Gas is pumped into the chamber, and the piglets lose consciousness and expire due to hypoxia and hypercapnia. Several methods of filling the chamber have been described, but the common terminology for fill rates includes: pre-filled chamber, slow fill with CO₂ gas, medium fill, and fast fill (2). According to a study performed at Iowa State University College of Veterinary Medicine, pre-fill and fast fill rates are preferable since they require the lowest amount of time to render the piglets insensible.

Pros	Cons
Bloodless technique	Piglet excitation/distress can be undesirable
Cost effective	Piglets will vocalize in distress
Hands-off technique once piglets are in chamber	CO ₂ is a respiratory epithelial irritant
Low to no risk to worker safety	CO ₂ from a tank can make the ambient atmosphere below freezing, causing the piglets lungs to freeze before they are fully insensible
100% efficacy when performed correctly	Homemade chambers can be unreliable, leading to need for adjunct methods of euthanasia to be utilized
	Routine maintenance and tank pressure checks are necessary to make sure enough CO ₂ is available at any given time

- 2. Carbon Monoxide:** Similar to CO₂, CO is used in conjunction with a chamber with a sealable lid and an inlet for the gas. Carbon monoxide cannot currently be used without a New Animal Drug Application (NADA) through the FDA since it alters the shape and action of hemoglobin. Due to the scrutiny from the FDA, all further research utilizing CO has been put on hold until a NADA is completed.

Pros	Cons
Similar to CO ₂	Similar to CO ₂
	Potential hazard to work safety

3. Alternative Gas Methods/Mixed Gas Inhalation: These methods are identical to CO₂, except they utilize another gas in conjunction with the CO₂. Examples of alternative gases used with the CO₂ include Argon (Ar), Nitrogen (N₂), and Nitrous oxide(N₂O). Ar, N₂, and N₂O are all inert gases with anesthetic properties, and that is the reason they were chosen as potential additives to the protocols (3). In a study to test the aversiveness of these gas mixtures, a mixture of 60% Argon, 30% CO₂, and 10% room air was found to be highly aversive to the piglets. The N₂ and N₂O methods were more acceptable based on piglet reaction and behavior when exposed to the gases. The final analysis showed and recommended the use of an N₂O/CO₂ mixture as more humane and aesthetic compared to CO₂ alone or a mixture of the other gases. Subsequent studies have also looked into the use of nitrous oxide as an anesthetic/euphoric agent prior to euthanasia with CO₂.

Another new technology in the mixed gas arena is a product introduced by Newfield Technologies. The product is called S2 and is a combination of an inhalant anesthetic agent and carbon monoxide (4). The product shows great promise in preliminary studies, however, they are bound by the FDA for another couple of years before the product can actually come to market.

Pros	Cons
More aesthetic than CO ₂	Anesthetic gases require FDA license to acquire
Piglets fall asleep or become euphoric before expiring	Potential for worker safety issues or intentional misuse
Similar to CO ₂ pros	Similar to CO ₂ cons

4. Electrocution: Electrocution is another option that has been extensively explored in the past few years. A few different techniques and contraptions have been used and described, but the general idea is a current traveling between two electrodes placed at the head and somewhere caudal to the heart of the pig. This current, if applied for an appropriate amount of time, will first cause an epileptiform insult. This causes an initial tonic (stiffened) phase in the piglet. A clonic phase will follow in which the piglet will paddle or have muscle fasciculations. The second effect of the current is cardiac fibrillations that ultimately cause death (5, 6).



Pros	Cons
Very fast method	Piglet tonic and clonic movements can be unsightly
Generally hands off	Concern for worker safety
Cost effective once a unit is in place	Only severely obtunded piglets can be safely restrained with this method

5. **Low Atmospheric Pressure Stunning (LAPS):** LAPS is a relatively new technique that has been adopted by the poultry industry. It was developed as a welfare response to the electrical stunning that was typically performed in slaughter facilities. In speaking with one of the engineers with the company that makes the device (TechnoCatch), the process was explained in detail. Basically, animals are placed in a sealed chamber similar, but more secure than a CO₂ chamber previously described. The chamber is then pressurized to forcibly remove the oxygen. The physiological response is mostly stress-free, in contrast with CO₂. The respiratory mucosa has receptors for high carbon dioxide, but not for anoxia. Because of this, the animals become “irreversibly insensible”.



Pros	Cons
Fast, aesthetic euthanasia	Cost: One unit, built to a sow farm scale runs \$75,000
Hands off	
No vocalizations and minimal paddling	

6. Non-Penetrating Captive Bolt (NPCB): This method of euthanizing piglets utilizes a device created by the University of Guelph in Canada. The device is similar to a captive bolt gun, with the obvious difference of not penetrating the skull and is called a Zephyr gun. Initially, the gun had a blunt, rounded tip. This led to some efficacy issues, and not all piglets were euthanized appropriately. The new model has a modified tip that, in several studies, has proven efficacy 100% of the time (7). The efficacy of this device in nursery-weight pigs is near 100%, but pigs larger than 40 pounds have sometimes required a secondary step to assure euthanasia. For this reason, the company recommends two, consecutive applications of the NPCB. Furthermore, a device resembling a sling which suspends the piglet and restrains it is recommended to promote easier access to the head and to decrease potential safety concerns.



Pros	Cons
Fast and humane euthanasia	Not currently approved by AASV as an acceptable euthanasia technique for piglets over 12 pounds, even though research has shown near 100% efficacy with just one use
High efficacy in pigs up to 40lbs	Need for a restraining device (sling) for non-obtunded piglets
Cost effective once the unit is purchased	
Mobile euthanasia device	

- 7. Electromagnetic Energy Euthanasia:** The exact tool utilized for applying the electromagnetic energy is not described in the research, but the basic premise is utilizing a device to apply electromagnetic energy to the head of the piglet to increase intracranial temperature and cause humane euthanasia. The technique was not effective 100% of the time, and alternative methods were used to euthanize some of the test subjects in the experiment.

Cost of available euthanasia devices and units:

1. Captive bolt gun:
 - a. Schermer Captive bolt stunners: \$1,180-\$1,550 (individual rounds equal \$0.24 per pig euthanized).
 - b. CASH Special captive bolt gun: \$1,967-\$1,988 (individual rounds equal \$0.28 per pig euthanized).
2. Commercially available CO2 chamber (Euthanex AgPro) \$2,950-3,300
3. Zephyr non-penetrating captive bolt:
 - a. Zephyr gun from University of Guelph (approved for rabbits): \$548.20
 - b. Zephyr gun from Bock Industries (approved for pigs up to 20lbs): \$998
 - c. TED Stunner (cordless with mini-propane canister and batteries → moisture sensitive): \$1,398

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