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.

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bloodless technique</td>
<td>Piglet excitation/distress can be undesirable</td>
</tr>
<tr>
<td>Cost effective</td>
<td>Piglets will vocalize in distress</td>
</tr>
<tr>
<td>Hands-off technique once piglets are in chamber</td>
<td>CO2 is a respiratory epithelial irritant</td>
</tr>
<tr>
<td>Low to no risk to worker safety</td>
<td>CO2 from a tank can make the ambient atmosphere below freezing, causing the piglets lungs to freeze before they are fully insensible</td>
</tr>
<tr>
<td>100% efficacy when performed correctly</td>
<td>Homemade chambers can be unreliable, leading to need for adjunct methods of euthanasia to be utilized</td>
</tr>
<tr>
<td></td>
<td>Routine maintenance and tank pressure checks are necessary to make sure enough CO2 is available at any given time</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Similar to CO2</td>
<td>Similar to CO2</td>
</tr>
<tr>
<td></td>
<td><strong>Potential hazard to work safety</strong></td>
</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>More aesthetic than CO2</td>
<td>Anesthetic gases require FDA license to acquire</td>
</tr>
<tr>
<td>Piglets fall asleep or become euphoric before expiring</td>
<td>Potential for worker safety issues or intentional misuse</td>
</tr>
<tr>
<td>Similar to CO2 pros</td>
<td>Similar to CO2 cons</td>
</tr>
</tbody>
</table>

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).
<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very fast method</td>
<td>Piglet tonic and clonic movements can be unsightly</td>
</tr>
<tr>
<td>Generally hands off</td>
<td>Concern for worker safety</td>
</tr>
<tr>
<td>Cost effective once a unit is in place</td>
<td>Only severely obtunded piglets can be safely restrained with this method</td>
</tr>
</tbody>
</table>

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
- Fast, aesthetic euthanasia
- Hands off
- No vocalizations and minimal paddling

### Cons
- **Cost**: One unit, built to a sow farm scale runs $75,000

#### 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.
<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast and humane euthanasia</td>
<td>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</td>
</tr>
<tr>
<td>High efficacy in pigs up to 40lbs</td>
<td>Need for a restraining device (sling) for non-obtunded piglets</td>
</tr>
<tr>
<td>Cost effective once the unit is purchased</td>
<td></td>
</tr>
<tr>
<td>Mobile euthanasia device</td>
<td></td>
</tr>
</tbody>
</table>

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
Cited References:


Non-cited References:

1. Millman, S. T. (2011). Euthanasia update: Tools, techniques, and training. Informally published manuscript, Department of Veterinary Diagnostic and Production Animal Medicine, Iowa State University, Ames, IA.


