Gas euthanasia methods in swine: Process and physiology

C. Scanlon Daniels, DVM, MBA
Circle H Headquarters, Dalhart, Texas

Introduction
The means by which swine are humanely euthanized are coming under increasing scrutiny by activist groups. Gas euthanasia using carbon dioxide (CO₂) is being increasingly adopted as a means of swine euthanasia due to concern regarding social acceptance of blunt force trauma. As swine veterinarians, it is our responsibility to be well versed in the methods available for swine euthanasia and their application.

"Is a lower intensity of aversiveness for a longer time worse than a higher intensity of aversiveness for a shorter time?"

"If aversiveness is felt, but not remembered, is it aversive?"

This paper is meant to be a factual review of what we “know” about gas anesthesia overdose or euthanasia of swine. However, engaging producers and veterinarians in discussions regarding euthanasia often leads to debate about personal values, rather than the scientific facts. The two questions posed above are included to illustrate this point.

Collectively, we need to be careful that our differences in personal values about pros and cons of various euthanasia methods do not get construed as a debate about the scientific facts. A quote from Hippocrates rings true:

“There are in fact two things, science and opinion; the former begets knowledge, the latter ignorance”

Body
Several gases and gas mixtures in various concentrations have been evaluated for pre-slaughter anesthesia (stunning) and/or euthanasia in swine. These include carbon dioxide (CO₂), carbon monoxide (CO), CO and nitrous oxide, CO₂ and nitrous oxide, CO₂ and argon (Ar), and Ar alone. Nitrogen has been assessed for euthanasia in dogs, rabbits and mink.

Carbon dioxide
Carbon dioxide is referenced as the sole gas anesthetic in the recently revised American Association of Swine Veterinarian and National Pork Board publication on swine euthanasia for producers. CO₂ from compressed gas cylinders is recommended. Dry ice as a gas source is discouraged. Gas flow from the cylinder is to be regulated so as to provide known and repeatable quantities of gas to the container. Chambers should be airtight, have a gas inlet in the bottom of the chamber and exhaust outlet(s) at the top of the chamber since CO₂ is heavier than room air. Chambers can be operated in two different manners: Pre-charged and gradual fill. In a pre-charging protocol, gas is turned on to the container, allowing CO₂ concentration to build up over time before pigs are placed in the chamber. When the gas level is suitable to initiate unconsciousness (> 30%), the lid to the chamber is opened and pigs are introduced to the chamber in a manner that minimizes gas disruption. The cover of the chamber is replaced, and gas flow resumed until it reaches 80-90%. Once gas flow reaches this level, the gas supply is turned off and pigs left in the chamber sufficiently long enough for death to occur, generally a minimum of 5 minutes. In the gradual fill protocol, pigs are placed in the chamber at the onset. The cover is placed, and gas flow initiated to the chamber. Gas flow should occur no slower than 20% of the chamber volume per minute until the concentration of CO₂ reaches 80-90%. This generally takes 2.5 chamber exchanges due to wash in-wash out function. As with the pre-charge protocol, gas supply is turned off and pigs left in the chamber a minimum of 5 minutes for death to occur. When exposed to low concentrations of CO₂, pigs demonstrate low degrees of aversion to the gas. At higher gas concentrations, the aversion is more noted. Aversion to 90% CO₂ was greater than 70% CO₂, but higher concentrations of gas resulted in lower amount of time to loss of posture, decreasing the time the aversive stimulus was perceived. Nonetheless, in pigs that were allowed to recover from unconsciousness after exposure to 90% CO₂, no aversion to CO₂ stunner crate was noted, indicating that memory of the event may not have existed. Additional detail about the physiologic effects of CO₂ on the brain of swine have been studied using electroencephalography (EEG) as well. Stress associated with induction of anesthesia has been measured using various concentrations of CO₂ and argon. After pigs
Carbon monoxide
Carbon monoxide (CO) is a colorless and odorless gas. It is non-flammable and non-explosive at concentrations less than 10%. CO results in euthanasia of animals by blocking uptake of oxygen by red blood cells, leading to hypoxemia. This gas is very dangerous for people, as it is very toxic and difficult to detect. With CO₂, compressed gas cylinders are the recommended source of CO. As with CO₂, visual signs of excitation are often present. Low flow rates help to minimize this expression. Gradual fill chambers are to be used in well ventilated areas to minimize human safety risk. CO induces unconsciousness insidiously, so animals appear unaware. Death occurs rapidly when concentrations of 4–6% are used. Electrical equipment in the vicinity of CO use must be explosion-proof due to the nature of this gas.

Nitrogen and argon
Nitrogen and argon are colorless and odorless gases that do not have the flammable properties of CO. Pre-charged or gradual fill chamber protocols may be used with these gases. As with CO₂, hypoxemia results as these gases displace oxygen in the chamber. Hyperventilation may be observed in some pigs prior to unconsciousness. With these gases, it is imperative that the chamber be airtight, as reestablishing a low concentration of oxygen will result in immediate recovery. While argon and nitrogen are commonly available gases, with a similar safety profile to humans as CO₂, their use is generally not recommended, as exposure times need to be longer than CO₂ to effectively euthanize pigs.

Conclusion
All of the gases reviewed in this paper can be used for the humane euthanasia of swine. Carbon dioxide is the most extensively studied and used in practice. It has a long history of use in slaughter facilities around the world and is being adopted in greater frequency by swine producers in the US.

Acknowledgements
The author thanks Dr. Christa Irwin and Gabe Young of Iowa State University for conducting a review and compilation of the relevant literature pertaining to euthanasia of swine. This work was funded by the American Association of Swine Veterinarians Foundation.

References
4. Forslid, A. 1987. Thesis entitled “Pre-slaughter CO₂-anaesthesia in swine.” Department of Physiology, Faculty of Veterinary Medicine, Swedish University of Agricultural Sciences, Uppsala, the Department of Clinical Neurophysiology, University Hospital, Lund and the Swedish Meat Research Institute, Kavlinge.


