factsheet
Pork Information Gateway

Alternative Euthanasia Methods to Manually Applied Blunt Force Trauma for Piglets Weighing Up To 12 lbs.

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Introduction

The most predominant method in the U.S. for euthanasia of non-viable piglets (less than 12 lbs.) is manually applied blunt force trauma (Ma-BFT). Manually applied blunt force trauma is one of several euthanasia techniques considered acceptable or conditionally acceptable by the American Veterinary Medical Association (AVMA, 2013). However, Ma-BFT is being criticized on the basis of aesthetics, impacts on those performing the procedure, and ability to produce humane euthanasia consistency. Alternative methodologies to Ma-BFT will be discussed in this fact sheet, highlighting benefits and challenges of these methods, along with implementation techniques.

Objective

To provide guidance for producers seeking alternative methods to manually applied blunt force trauma for piglets weighing up to 12 lbs [5.44 kg].

Background

Swine producers, veterinarians and animal scientists, among others, generally agree that euthanasia is the best choice for low viability piglets, especially when there is suffering due to injury or illness. The USDA estimates ~120 million piglets are born yearly in the United States [1]. The average sow gives birth to ~12 live piglets per litter, but weans 10 [2]. Thus, an estimated 20 million piglets do not survive to weaning yearly in the U.S. More than half of these deaths occur in the first 3 days after birth due to causes such as crushing by the sow or are euthanized by caregivers [3]. Low viability piglets may be afflicted with physiological ailments, deformities or are underdeveloped. Additionally, despite being provided optimal care some piglets will become ill or injured, and in turn, will have little prospect of recovery. Piglets that fall into these aforementioned categories are likely to experience suffering, thus becoming candidates for euthanasia.

The term euthanasia is derived from the Greek language meaning "good death," and defined by the Merriam-Webster Dictionary as "the act or practice of killing or permitting the death of hopelessly sick or injured individuals in a relatively painless way for reasons of mercy" [4]. Similarly, euthanasia is described by the AVMA as "… ending of life of an individual animal in a way that minimizes or eliminates pain and distress" [5]. Death should be achieved through rapid loss of consciousness, and then cessation of cardiac and respiratory functions, followed by loss of brain function. The AVMA highlights several areas for assessing the acceptability of euthanasia methods, including (1) the ability to induce loss of consciousness and death without causing pain, distress, anxiety or apprehension, (2) time required to induce loss of consciousness, (3) reliability, (4) compatibility with species, age and health status, and (5) emotional effect on observers or operators, and others.

Mechanically Applied Blunt force trauma is a 'physical method', with unconsciousness and death achieved through damage to the brain via concussive forces. There are several benefits to Ma-BFT, it can be conducted in a timely manner, thus ensuring piglet welfare, and it is inexpensive, making it a popular choice. However, in 2013, the AVMA noted that persons performing this method might become fatigued, which could lead to inconsistency in application creating humane concerns. The AVMA recommends producers currently utilizing Ma-BFT "… actively search for alternative approaches" [5]. Subsequently and in response to undercover videos highlighting Ma-BFT, several purchasers and suppliers of pork required producers to eliminate this practice [6-8]. Because of these factors, many producers are seeking advice on alternative methods of euthanasia for this piglet weight class.

Alternative 1: Gas Euthanasia

Gas euthanasia is approved by both the AVMA and NPB for all age and size categories of pigs; however, due to implementation issues, on farms it is often not practical to apply gas euthanasia to pigs past the nursery phase. Loss of consciousness and death result from a decrease in the pH of the body or from a lack of oxygen. Although CO_2 appears aversive to piglets during the brief period before unconsciousness occurs, escape attempts are rare. Caregivers may hear noises coming from the box, and these noises typically result from the normal involuntary movements that occur after the pig has become unconscious, no longer in control of its limbs, and no longer able to feel pain. It is important to recognize these movements are normal and not likely to be an indicator of piglet distress or pain if gas concentrations are maintained according to the protocol. Post application, death should be confirmed via cardiac and respiratory arrest. Those conducting the procedure should be familiar with expected behavioral indicators of the procedure, allowing intervention if it falls outside of expected values (Table 1). As with all methods, death should be confirmed ensuring application was successful. With gas, death should be confirmed approximately 15 minutes after first exposure to the gas.

If implemented incorrectly, gas euthanasia has the potential to be highly aversive and painful to the piglet, thus it is critical that all procedures be followed to minimize pain and distress. To achieve the goal of minimal distress, there are a few required components: a sturdy, comfortable box, a gas regulator, and a flow meter capable of producing the gas volume required.

Gas type: Carbon dioxide (CO_2) is identified as an acceptable inhalant method of euthanasia for piglets on the basis that it is a rapid depressant with established analgesic and anesthetic properties [10]. Carbon dioxide gas can be purchased through many local welding or brewery suppliers. Carbon dioxide is mildly acidic, and may irritate the mucus membranes of mammals. Some humans exposed to high concentrations of CO_2 report it to be painful and unpleasant, causing a sense of breathlessness [11], thus following identified best practices is critical to ensure distress is minimized when using this gas. Refinements to these procedures using CO_2 or alternative gases such as argon and nitrogen are being explored. The procedures below represent the best practices based on current research.

Flow rate: The current AVMA guidelines for pigs recommend utilizing a prefill or slow flow rate (10-30% box exchange rate) [5]. However, current research has yet to iden-

Table 1. A practical guide to the sequence of behaviors that may be observed during CO_2 gas euthanasia of suckling piglets at 50% chamber volume exchange rate [9]

Piglet is:	Parameter*	Latency to expected behaviors (seconds)		
		Avg.	Min	Max
conscious	1. Relative calm	–	–	–
	2. Vigilance	–	–	–
	3. Labored/Open mouth breathing	45	23	71
	4. Agitation & movement; may include vocalization and escape attempts	–	–	–
	5. Ataxia	42	23	76
~ loss of consciousness	6. Loss of posture	74	55	109
unconscious	7. Clonic/paddling	76	55	111
	8. Gasping	78	55	87
	9. Limbs stop moving	~ 200	28	280
	10. Breathing stops	~ 350	178	290
	11. Heart Stops	~ 800	N/A	N/A

*Not all behaviors will be observed for each individual piglet
The process will vary from piglet to piglet; times are listed sequentially
N/A = information is not available
A dash (-) = extreme variability between individual pigs, yet in causal observation it will generally occur in the order listed

tify CO_2 concentrations that are not associated with aversive behavioral responses of piglets. Furthermore, a prefilled environment is difficult to create with existing on-farm euthanasia equipment [12]. Hence, piglet welfare is likely better at faster flow rates (50% box volume exchange rate) that balance duration of exposure and intensity of response.

Flow meters and gas regulators are necessary components to ensure reliable gas flow rates. This equipment can be purchased from local welding suppliers or found online. Because of the volume of gas utilized and the properties of CO_2, freezing of the flow meter is a common problem, hence, a heated flow meter or a regulator is advised. Often heated flow meters and gas regulator combinations can be purchased for $200 to $600. Examples of flow meter can be found on the following website: *http://www.arc-zone.com.*

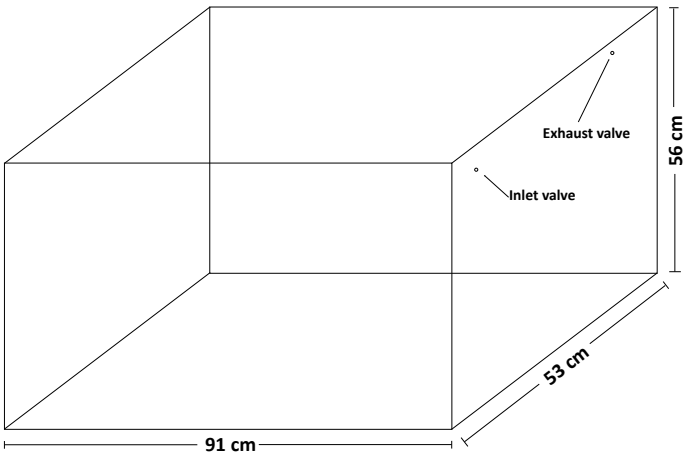


Figure 1. Example dimensions of a box for suckling pigs with inlet and exhaust values indicated.

Since high volume flow meters are typically capable of flow rates up to 125 cubic feet per hour, a single flow meter will produce a 50% box volume exchange rate for a 4 cubic feet box (2′ × 2′ × 1′). If a larger box is desired, more than one flow meter can be fitted to the box. Hoses adequate for the pressure and temperature extremes produced by CO_2 can be purchased from the supplier of the flow meter. The inlet and exhaust ports should be placed near the top of the box reducing the potential of a pig or debris blocking the ports (Figure 1). CO_2 gas is heavier than air, thus even when inlets are placed at the top, the box will still fill from bottom to top. Exhaust hoses should vent to the outdoors.

Table 2. Floor space recommendations for pigs*

Avg. Weight (lbs.)	Square Feet Per Head
12	0.65
50	1.53
100	2.32
150	2.95
200	3.48

Adapted from, Transport Quality Assurance Handbook, version 4, National Pork Board Average pig shoulder height and width by pig weight

Box: The box should be of adequate size to allow the piglet to stand comfortably and turn around (Table 2). We recommend floor space guidelines consistent with pig transportation (Table 3). The box should allow the piglets adequate headroom to make head thrusts without hitting their head on the top of the box. Research indicates that stocking density within the box has minimal effect on piglet responses to gas euthanasia [13]. However, piglets euthanized singly displayed behavior consistent with isolation distress. The box should be free of pinch and protruding points that may cause pain. During the gas euthanasia process, piglets will produce strong involuntary movements (very strong clonic convulsions), thus it is critical that the box is sturdy and capable of withstanding this force. If the box becomes cracked or damaged, maintaining a gas concentration may become difficult. Additionally, this damage may create pinch points causing pain. The price of the box will be the largest variable when costing the system, depending on material and size. If biosecurity is not a concern, one could be constructed with minimal expense utilizing plywood and caulking to ensure no gas leaks. However, more robust and cleanable boxes can be purchased from many suppliers. The flooring should be non-slip. This can easily be achieved by placing a rubber truck mat cut to the size of the box's floor. This mat will also aid in cleaning and sanitizing of the box.

Table 3. Average pig should height and width by pig weight*

Weight (lbs.)	Shoulder width (in)	Shoulder height (in)
11	4	11
22	5	13
44	7	17
66	8	19
88	9	21

Please note: values given are not box dimensions; instead, they represent an average pig. Additional height and width need to be provided to allow the pig to turn around and lift its head
** Adapted from, For Pigs, Size Really Does Matter. The Pig Site. Available at: thepigsite.com/articles/884/for-pigs-size-really-does-matter*

Temperature: Research indicates temperature within the box is minimally affected when utilizing a flow rate up to a 50% box volume exchange rate [14]. Consideration should be given to the location of the box, ensuring thermal neutral temperatures are provided during the process. CO_2 gas is very cold if "dumped" into the box at an uncontrolled flow rate, which is likely to create an aversive temperate that is distressing to the piglet.

Lighting: It is currently unknown if the piglet would prefer a dark or lighted environment during the gas euthanasia process. However, it is recommended the box be sufficiently lit with an observation window to allow the process to be monitored. Those performing the procedure have the ability to ensure that the process is running within expected outcomes. In the absence of a window caregivers must open the lid resulting in atmospheric air entering the box which displaces the CO_2 [15].

Benefits: A benefit of gas euthanasia, in relation to piglet welfare, is that a relatively low level of restraint is required and being placed in a box allows the piglets to maintain normal behaviors and postures. Another welfare benefit is the high efficacy (100%) with minimal distress when proper procedures are followed; additionally, if deviations do occur, the piglet is often anesthetized allowing time to implement corrective action. In relation to human factors, though euthanasia is never easy, many caregivers find this method less mentally fatiguing than the physical methods; this may aid in timely euthanasia decisions, with caregivers more willing to euthanize. Human safety concerns are minimal with this method if conducted in a properly ventilated location.

Challenges: The gas euthanasia process can be difficult for several reasons. First, the piglet will take longer to lose consciousness than with physical methods, which can be distressing for caregivers performing the procedure. Second, gas euthanasia systems are difficult to transport due to their size. If using stationary systems, piglets will likely need to be transported to the unit. It is important that caregivers recognize that the potential inconvenience of this distance is not a reason to delay euthanasia; procedures should be developed that ensure timely euthanasia regardless of system implemented.

Costs: Currently there is a single supplier for a piglet purpose designed gas euthanasia device (Figure 2), which is distributed by V-ast (Mason City, Iowa; *http://www.v-ast.com/euthanex.aspx*). Two box size options are available for $2,950 and $3,250 (priced in 2013). Gas euthanasia is the only listed euthanasia option that allows producers to create their own system, potentially reducing initial investment costs. Construction of the gas euthanasia system will vary in cost, ranging from less than $300 to over $1000. To operate the system, CO_2 will need to be purchased. The cost of operating the box on a per piglet basis will vary depending on the size of the box (Figure 3 & 4) and operational procedures. In general, cost per piglet will be less than $0.10.

Alternative 2: Nonpenetrating captive bolt

Similar to Ma-BFT, nonpenetrating captive bolt is a 'physical method', and is approved by both the AVMA and NPB for piglets up to 12 lbs. Nonpenetrating captive bolt devices are powered by cartridges (Cash Special, Schermer), pneumatic (Zephyr-E), or battery/fuel (TED). Loss of consciousness and death occur as a result of concussive forces; however, unlike Ma-BFT the nonpenetrating captive bolt allows for greater caregiver control and decreased fatigue. The target site on the piglet for placement of a nonpenetrating captive bolt is indicated in Figure 5. The nonpenetrating captive bolt must be placed flush and firmly against the piglet's skull. Restraint of the pig is an important consideration and critical to proper application. Loss of consciousness should be nearly instant upon application. The piglet should be monitored for return to consciousness until death is confirmed via cessation of respiratory and cardiac function. Anything other than immediate loss of consciousness should be considered a major failure, as this will result in painful physical damage and requires a planned corrective action be

Figure 2. Euthanex AgPro

Figure 3. Cost of CO_2 per cycle, by size of box

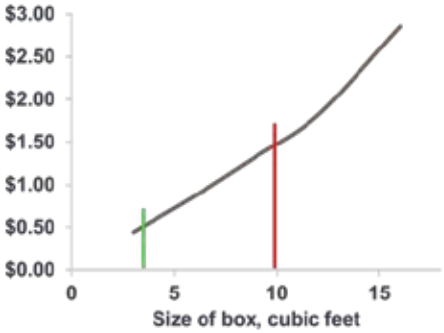
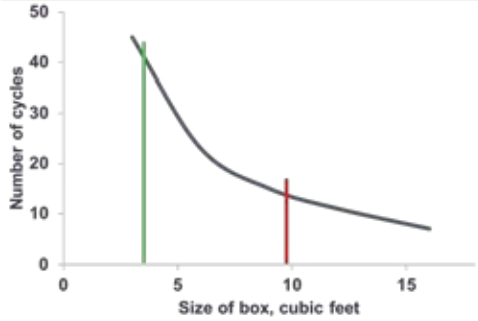


Figure 4. Number of cycles that can be completed with one 50# CO_2 cylinder, by size of box



Maximum box size for a 50% box volume exchange rate, if box is equipped with a single 125 CFH flow meter. Up to 8 small suckling pigs may fit in a box this size, $0.05/pig

Maximum box size for a 20% box volume exchange rate if box is equipped with a single 125 CFH flow meter

Assumptions: 2.5T required to achieve 90% concentration, $20 for 50# of CO_2, 20% gas loss.

immediately applied. This corrective action could include a second shot.

Those conducting the procedure should be familiar with expected behavioral indicators of the procedure, allowing intervention if it falls outside of expected values (Table 4).

Benefits: Nonpenetrating captive bolts are portable, fast in their application, and result in instantaneous loss of consciousness. Some caregivers prefer this instantaneous loss of unconsciousness that is not created with gas euthanasia.

Challenges: Immobilization of the piglet is required and after successful application piglets display intense involuntary movements (paddling) that can be aesthetically displeasing. Caregivers may find this physical act emotionally challenging to perform. This method also presents an increased safety hazards to caregivers due to the close proximity between site of application and restraining area inherent with a small pig. While research indicates very high efficacy (100%, [14]), based on the author's experience with this methodology, even when following procedures with care, a small number of piglets may require a corrective step to ensure a humane death. This corrective step may include a second application of the nonpenetrating captive bolt. Lack of maintenance and improper storing of equipment may lead to poor performance. This equipment requires frequent maintenance, cleaning, and low humidity storage to ensure proper function.

Table 4. A practical guide to the expected latency to cessation of activity when utilizing blunt force trauma

	Nonpenetrating captive bolt (Zephyr-E) applied blunt force trauma [14]			Manually applied blunt force trauma [16]		
Parameter*	**Avg.**	**Min.**	**Max.**	**Avg.**	**Min.**	**Max.**
1. Resistance to restraint	N/A	N/A	N/A	N/A	N/A	N/A
Method applied						
2. Loss of consciousness	0	0	0	0	0	0
3. Clonic movement	101	0	225	N/A	N/A	N/A
4. Last movement	229	23	570	313	108	1236
5. Heart stops	420	—	900+	—	—	—

*All values assume application of the technique resulted in immediate loss of consciousness;
— = data not available for this parameter
N/A = values are not available for this measure, though they do occur with this euthanasia method.

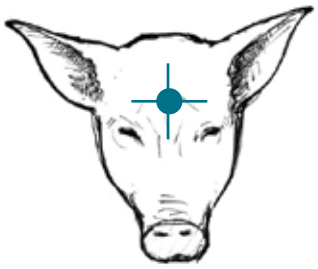


Figure 5. Depiction of proper placement for nonpenetrating captive bolt, unlike gun shot, it is critical the gun be placed firmly against the skull[13]

Figure 6. Modified PVC pipe for holding pigs during application of nonpenetrating captive bolt[13]

Commercially available nonpenetrating captive bolt equipment: Several new products have come on the market (Table 5). All products have undergone manufacture and third party testing using the pig as a model. These products are highly reliable and effective. However, the cost of these products may make them prohibitive for some producers. Apart from snares, the authors are unaware of any commercially available equipment that is commonly used by producers for restraining piglets. However, some producers have created their own devices, such as a modified PVC pipe (Figure 6).

Penetrating captive bolt, Gunshot and Electrocution

While recognized as a humane and effective method for euthanasia of pigs, penetrating captive bolt and gunshot are not identified as acceptable for piglets 12 lbs. or less in the AVMA or NPB guidelines. The exclusion of these methods for this size of piglet is unclear. Because electrocution does not reliably result in death of small animals, this method is not approved by the AVMA for animals less than 11 lbs. Similarly, NPB does not approve electrocution for piglets less than 10 lbs. [14]

Table 5. Commercially available Nonpenetrating captive bolt guns

Gun Name	Description	Estimated cost	Additional materials needed for operation	Website/contact info	Graphic
Cash Special	pistol type	$1,600	Charge/shell ($200/ 1000 charges), cleaning kit and cleaning chemicals. Additional heads can be purchased allowing this tool to be utilized on all pig age/size categories	*bunzlpd.com* *jarviscanada.com* Charles Bildstein, *Charlies.Bildstein@bunzlusa.com*	
Schermer	inline type	$1,500	Charge/shell ($200/ 1000 charges), cleaning kit and cleaning chemicals	*karl-schermer.de* *hantover.com*	
TED	battery and fuel powered	$1,000	Battery (provided), fuel cell ($10, each cell fires ~ 1000 times)	*tedstunner.com* Bock Industries, 814-342-4383	
Zephyr-E	pneumatic	$700	Air compressor, air hose with connector	*tedstunner.com* Bock Industries, 814-342-4383	

All nonpenetrating captive bolt methods require some method/additional materials to properly restrain the piglet. Currently, commercially available equipment for this purpose is limited. All costs are approximate, estimated in November 2013

Summary

Currently, there are several viable options to replace Ma-BFT, however these all involve a relatively high initial investment. In general, producers are left with two viable options, gas euthanasia and nonpenetrating captive bolt. Recognizing effectiveness of the method for inducing euthanasia with the least piglet suffering is of highest importance and researchers continue to examine this issue. In addition to cost and animal welfare, decisions about alternatives to Ma-BFT should consider effects on caregivers and implications for timely euthanasia decision-making.

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Frequently Asked Questions

Q. When utilizing gas euthanasia, are all sounds heard from the box indications of escape and distress by the piglet?

A. Caregivers may hear noises coming from the box, and these noises typically result from the normal involuntary movements that occur after the pig has become unconscious, no longer in control of its limbs, and no longer able to feel pain. It is important to recognize these movements are normal and not likely to be an indicator of piglet distress or pain if gas concentrations are maintained according to the protocol.

Q. Is one of the benefits to gas euthanasia the elimination of the need to check for sensibility and death post procedure?

A. As with all methods, death should be confirmed ensuring application was successful.

Q. How long after initializing gas euthanasia should I wait before confirming death?

A. Death should be confirmed approximately 15 minutes after first exposure to the gas.

Q. Where can carbon dioxide (CO_2) be purchased from?

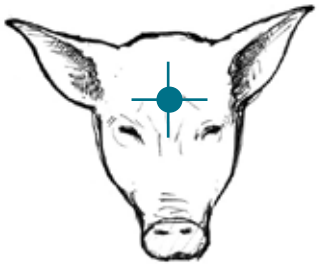
A. Carbon dioxide gas can be purchased through many local welding or brewery suppliers.

Q. What flow rate is currently recommended for piglet euthanasia?

A. Piglet welfare is likely better at faster flow rates (50% box volume exchange rate) that balance duration of exposure and intensity of response.

Q. What is the target site when utilizing non-penetrating captive bolt?

A. The target site on the piglet for placement of a non-penetrating captive bolt is at right:



Q. After application of the non-penetrating captive bolt, when should you check for sensibility?

A. Immediately or as soon as it is safe to verify.

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