RESEARCH REPORT
ANIMAL WELFARE

Title: Determine and Validate the Optimal Requirements and Duration of Time to Achieve Unconsciousness and Euthanasia in Pigs from Birth to 15 Pounds with a Novel Electrocution Device - **NPB #**: 10-077

Investigator: Sarah Probst Miller, DVM, Swine Veterinarian

Institution: Carthage Veterinary Service, Ltd.

Date Submitted: September 3, 2010

Industry Summary

It is inevitable in every swine production system young pigs not recovering from disease, weakness, or trauma will need to be euthanized in a timely, humane, and safe manner. The industry continues to be scrutinized about how euthanasia can be effectively accomplished. This can be especially problematic with suckling pigs. Currently approved methodologies such as blunt force trauma, non-penetrating captive bolt, and carbon dioxide receive heavy criticism from consumers and animal rights organizations. Additionally, these methods may impact the caregivers' well-being and psychology.

Electrocution induces a loss of consciousness in a rapid, timely manner, and requires little training[3]. Electrocution, if effectively administered will render the brain insensible and initiate cardiac fibrillation and death[1]. Traditionally, electrocution has not been used on young pigs under 10 pounds because the resistance around the skin can be less than that across the body causing the electrical current to flow on the skin's surface rather than through the body. Preliminary trials of the electrode design of S & R Resources, LLC appear to overcome the previous disadvantage. In addition, this novel device is equipped with user safety features that limit the chance of electrical exposure to the user. The focus of this research was to validate that this novel electrocution device provides a safe, humane alternative to current euthanasia methods available for young pigs from birth to 15 pounds.

The first consideration with euthanasia via electrocution is validating that the method causes a rapid loss of consciousness (Phase I). Initially, a minimal time to loss of consciousness was determined for 2 different times of electrocution in 3 different age and weight groups: Pigs less than 3 days of age and less than 5 pounds (n=10), pigs greater than 3 days of age and less than 5 pounds (n=10), and pigs greater than 3 days of age and greater than 5 pounds (n=10). Thirty commercial pigs ranging from birth to 15 pounds were identified as being ill, unthrifty, or fallouts. These animals were lightly anesthetized to Stage 3 Plane 1 (palpebral responses present) prior to electrocution[5]. They were then placed in the electrocution device and a 110-120 voltage alternating current (VAC) was applied for 3 or 5 seconds. Parameters measured included tong placement relative to weight, voltage, and amperage. Cardiac and brain electrical activity were monitored using an electrocardiogram and an electroencephalogram, respectively. All electrocutions were videotaped and motor activities such as kicks,

paddling, gasps or vocalization were recorded. Additionally, the pigs were evaluated for dilation of pupils, absence of corneal reflexes, and absence of nociceptive reflexes to determine unconsciousness to the level of Stage 3 Plane 2 (surgical loss of consciousness)[5]. If this level of loss of consciousness was confirmed in a specific age/weight group, that cohort was allowed to remain in the study. The electrocution device was successful in inducing a loss of consciousness in all pigs at 5 seconds and 3 second duration for the groups >3 days of age, <5 pounds and >3 days of age, > 5 pounds. However, the <3 days, < 5 pound cohort was eliminated from Phase II of the trial due to a poor stunning success rate (70% success) at the 5 second electrocution interval. Any pigs that did not lose consciousness by electrocution were immediately and humanely euthanized via Pentobarbitol injection. If a pig started to regain consciousness after loss of consciousness, these pigs were also humanely euthanized.

In Phase II of the trial, 66 commercial sick pigs (>3 days of age, <5 pounds; and >3 days of age, > 5 pounds) were sedated and euthanized via electrocution at time intervals of 5, 10, and 15 seconds. The same monitoring equipment and data collection parameters were used as in Phase I. Successful death events were recorded in 98.5% of pigs. The one unsuccessful euthanasia occurred in the >3 days of age and <5 pound group at 15 seconds.

Caregiver well being during implementation and emotional response to the perception of the quality of death is an important consideration of the euthanasia method and design of this novel device. One of the disadvantages of electrocution euthanasia is that there is sudden stiffening and extension of the limbs, head, and neck[2]. This device is designed with a door that will block the caregiver's view of the pig during the electrocution and is also a safety feature. The other most common involuntary reflex observed was occasional pig gasps (53%) or singular kicks (9.1%) after Stage 3 Level 2 unconsciousness and during and/or after death.

This study indicates that electrocution using this novel device is a humane form of euthanasia when carried out in piglets greater than 3 days of age. Electrocution reliably induced unconsciousness at less than or equal to 3 seconds after the application of current. Additionally, electrocution repeatedly induced death in piglets greater than 3 days of age at time periods equal to or greater than 5 seconds of current application.

This research was funded by the National Pork Checkoff. Any questions may directed to: Sarah Probst Miller, DVM at probst@hogvet.com A special thanks goes to project co-investigators: Aaron Lower, DVM, Carthage Veterinary Service;, Sherrie Clark, DVM, PhD, University of Illinois; and student intern Jessica McKinney, University of Illinois College of Veterinary Medicine. We also thank the other student interns who assisted with the trial.

Keywords
Euthanasia
Electrocution
Humane
Welfare
Consciousness

Scientific Abstract

Electrocution induces a loss of consciousness in a rapid, timely manner, and requires little training[3].Electrocution, if effectively administered will render the brain insensible and initiate cardiac fibrillation and death[1]. Traditionally, electrocution has not been used on young pigs under 10 pounds because the resistance around the skin can be less than that across the body causing the electrical current to flow on the skin's surface rather than through the body. Preliminary trials of the electrode design of S & R Resources, LLC

appear to overcome the previous disadvantage. In addition, this novel device is equipped with user safety features that limit the chance of electrical exposure to the user. The focus of this research was to validate that this novel electrocution device provides a safe, humane alternative to current euthanasia methods available for young pigs from birth to 15 pounds.

The first consideration with euthanasia via electrocution is validating that the method causes a rapid loss of consciousness (Phase I). Initially, a minimal time to loss of consciousness (Stage 3 Plane 2)[5] was determined for 2 different times of electrocution in 3 different age and weight groups. Loss of consciousness for this measurement was defined as movement from Stage 3 Plane 1 (light anesthesia) to Stage 3 Plane 2 (surgical anesthesia) [5]. Thirty commercial pigs ranging from birth to 15 pounds were identified as being ill, unthrifty, or fallouts. Parameters measured included tong placement relative to weight, voltage, and amperage. Cardiac and brain electrical activity were monitored using an electrocardiogram and an electroencephalogram, respectively. Pigs were evaluated for dilation of pupils, absence of corneal reflexes, and absence of nociceptive reflexes to determine Stage 3 Plane 2 unconsciousness. The electrocution device was successful in inducing a Stage 3 Plane 2 loss of consciousness in all pigs at 5 seconds and 3 second duration for the groups >3 days of age, <5 pounds and >3 days of age, > 5 pounds. However, the <3 days, < 5 pound cohort was eliminated from Phase II of the trial due to a poor stunning success rate (70% success) at the 5 second electrocution interval. Any pigs that did not lose consciousness by electrocution were immediately and humanely euthanized via Pentobarbitol injection.

In Phase II of the trial, 66 commercial sick pigs (>3 days of age, <5 pounds; and >3 days of age, > 5 pounds) were sedated and euthanized via electrocution at time intervals of 5, 10, and 15 seconds. The same monitoring equipment and data collection parameters were used as in Phase I. Successful death events were recorded in 98.5% of pigs.

This study indicates that electrocution using this novel device is a humane form of euthanasia when carried out in piglets greater than 3 days of age. Electrocution reliably induced unconsciousness at less than or equal to 3 seconds after the application of current. Additionally, electrocution repeatedly induced death in piglets greater than 3 days of age at time periods equal to or greater than 5 seconds of current application. Caregiver well being during implementation and emotional response to the perception of the quality of death is an important consideration of the euthanasia method and design of this novel device. To reduce the incidence of involuntary gasps and kicks post electrocution, it would be recommended to electrocute pigs greater than 3 days of age for duration of 10 seconds.

Introduction

As the National Pork Board research initiative for animal welfare states, it is inevitable that in every swine production system, animals will become ill or injured in such a way that euthanasia will be necessary. If it is determined a pig will not recover, it is of high priority that the pig be humanely euthanized. This is especially problematic with suckling pigs. Currently approved methodology receives heavy criticism from consumers and animal rights organizations. Additionally, this may impact a caregivers' well-being and psychology.

An overview of currently approved methods of euthanasia has been developed by the American Association of Swine Veterinarians and National Pork Board in the On-Farm Euthanasia of Swine – Recommendations for the Producer publication[1]. In suckling pigs, carbon dioxide, non-penetrating captive bolt, anesthetic overdose, and blunt force trauma are approved methods of euthanasia. Electrocution can only be used in pigs greater than 10 pounds. In the farrowing house, the most common methods of euthanasia that we observe in the industry are blunt force trauma and carbon dioxide. Blunt force trauma is a quick method of euthanasia; however, errors in application resulting in an increased time to death and poor aesthetics. Carbon dioxide is a method with presumed superior aesthetics to the caregiver but time to unconsciousness and subsequent death are variable and

subjective to application methods. Additionally, animal welfare organizations have published numerous videos over the past 2 years painting the common practices of blunt force trauma and carbon dioxide euthanasia in a negative light.

In the AVMA guidelines of humane euthanasia, the method must adhere to the following criteria during euthanasia: "1) 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) safety of personnel; 5) irreversibility; 6) compatibility with requirement and purpose; 7) emotional effect on observers or operators; 8) compatibility with subsequent evaluation, examination, or use of tissue; 9) drug availability and human abuse potential; 10) compatibility with species, age, and health status; 11) ability to maintain equipment in proper working order; and 12) safety for predators/scavengers should the carcass be consumed[2]" Electrocution induces a loss of consciousness in a rapid timely manner, does provide safety to personnel, and requires little training[1,2].

Electrocution, if effectively administered will render the brain insensible and initiate cardiac fibrillation and death[1]. Electrocution will induce an epileptiform insult and "an animal is unconscious after electrical stunning if a general epileptiform insult occurs[3]." In Denicourt's 2006 study, a majority of pigs were unconscious at 5 seconds and did not recover consciousness. Electrocution using a one-step process with 110-120 VAC in a 15 second interval proved to ensure death without pain and distress to the pig[4]. Additionally, this one-step procedure increases the safety of the operator, because the operator does not have to reposition tong placement. The operator should not have to touch the pig during the process of electrocution. It is an easy, painless and rapid procedure [4].

Objectives

The objective of this study was to determine and validate the optimal requirements and duration of time needed to achieve Stage 3 Plane 2 unconsciousness and euthanasia in pigs from birth to 15 pounds with a novel electrocution device. This involved two groups of parameters that we measured in Phase I (Stage 3 Plane 2 loss of consciousness) and Phase II (current duration required to result in death) of the trial.

Mechanical parameters measured for the novel electrocution device

a. Location of tongs dependant on pig weight or age
b. Validation of voltage
c. Validation of frequency (hertz)
d. Determine current (amperage) dependant on pig weight or age
e. Establish human safety

Biological Parameters Measured in an effort to establish that the novel electrocution device meets standards of humane electrocution death established by Martine Denicourt's 2009 research[3].

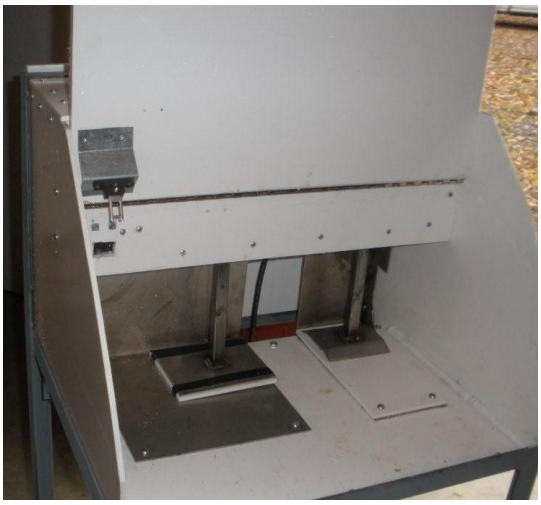
a. Confirmation of Stage 3 Plane 2 loss of consciousness (Phase I)
b. Interval until Stage 3 Plane 2 loss of consciousness (Phase I)
c. Confirmation of death (Phase II)
d. Determine optimal duration of electrocution per weight range (Phase II)
e. Reliability and repeatability (Phase II)

Materials and Methods

A novel apparatus has been designed to carry out electrocution euthanasia for piglets from birth to 15 pounds. This mobile device includes a resting table which has two sets of spring loaded tongs which simultaneously open as the user depresses a foot pad and closes as the user gently removes the foot pressure on the foot pad (Figures 1-2).

Figure 1: Suckling pig needing to be humanely euthanized in device prior to electrocution.

Figure 2: Safety lid



Both tongs have the ability to be a positive or negative charge as well as both resting plates on the table. In this trial, the tong and resting plate by the head of the pig were positively charged while the tong and resting plate located distal to the head were negatively charged. The flow of electricity is designed to pass diagonally and simultaneously through the brain and through the heart.

To euthanize a pig, the technician gently handles both front legs of the pig with one hand and both back legs with the other hand. The user depresses the foot pad and places the pig on the resting table with one electrode plate on the base of the ear and with the other electrode plate on the pig's chest or caudally depending on the pig's size.

The weight on the foot pad is removed and the pig lies firmly in place on its side. The technician then shuts a door which protects the user from contact with electricity. The door's safety latch prevents euthanasia by electrocution until the door is completely shut. If the user were to open the door before the time of electrocution is up, the current is disconnected. Once the door is shut, the user then pushes a button which delivers electricity to the pig for a predetermined amount of time. A large red light on the control panel indicates when the unit is on. Once the time limit is up, the red light on the control panel shuts off. The door is opened, the foot pad is depressed and the pig is removed. The system is equipped with a 3 amperage breaker.

<u>Location of tongs (electrodes) dependant on pig weight</u>

All pigs were placed in the device with the cranial tong at the base of the ear. Measurements from the poll of the head to the caudal tong on each animal were taken. This measurement was to determine if there was variation in the location of the head placement between pigs. All pigs were placed in the device by the same technician. Secondly, rib measurements at the cranial edge of the caudal tong were taken to measure positive or negative effect of caudal electrode placement on device effectiveness in regards to Phase I (Stage 3 Plane 2 loss of consciousness) and Phase II (death). Pictures were collected from all pigs in their respective weight and age ranges:

1. Pigs less than 5 pounds (<3 days of age)
2. Pigs less than 5 pounds (>3 days of age)
3. Pigs greater than 5 pounds (>3 days of age)

Validation of Voltage

The testing was carried out at 110-120 VAC. A multimeter (Amprove 33XR-A) was used to record the peak voltage during all electrocutions.

Validation of frequency (hertz)

A multimeter (Amprove 33XR-A) was used to record and validate that the electrical current running through the device was 60 hertz.

Determine current (amperage) dependant on pig weight

A multimeter (UEI DL49) measured the amperage of the unit to determine the maximum amperage reading during the electrocution dependant on the pig's weight/age.

Confirmation of loss of consciousness at 3 and 5 seconds

In Phase I, minimal time to Stage 3 Plane 2 loss of consciousness was determined. For this experimental part of the study, 30 pigs were sedated using a combination of acepromazine (2.2 mg/kg), ketamine (11mg/kg) and atropine sulfate (0.04 mg/kg). 5 pigs per age/weight group were electrocuted at a voltage of 110-120 VAC for 5 seconds and successful movement from Stage 3 Plane 1 to Stage 3 Plane 2 was measured. Then, 5 pigs per age/weight group were electrocuted at 3 seconds and successful Stage 3 Plane 2 loss of consciousness was measured. Any animal that was still conscious after stunning was immediately humanely euthanized via Pentobarbiol to effect. If animals in a group were not rendered Stage 3 Plane 2 unconscious at an acceptable rate, that group was eliminated from phase II of the study.

Cardiac electrical activity was monitored by an electrocardiogram (ECG) and cerebral electrical activity was monitored with an electroencephalogram (EEG) prior to euthanizing the animal to confirm normal cardiac and brain function. All electrocutions were videotaped to have a documented record of the trial and the ability to review the footage. During the electrocution, the duration of the tonic and clonic phases were measured. Any motor activity including kicks and paddling movements, gasps or vocalization was recorded. Immediately after the electrocution, dilated pupils, absence of corneal reflexes, absence of nociceptive reflexes, and absence of pain reflexes were recorded and used to determine unconsciousness. An ECG was monitored immediately post electrocution to confirm irreversible cardiac fibrillation and an EEG was used to monitor brain activity. After confirmation of fibrillation and an absence of reflexes, death was assumed. Pigs were then visually monitored for 5 minutes and assessed at the end of that time period to confirm fibrillation had ceased and death had occurred.

Determination of optimal time to death via electrocution with novel device for various pig weights and interval until death

In Phase II, 66 commercial sick pigs from a variety of farms were euthanized at various weights/ages and time duration. The group from Phase I; <3 days of age, <5 pounds was eliminated from the study in Phase II due to an inability to confirm a Stage 3 Plane 2 loss of consciousness at an acceptable rate. All pigs were lightly

anesthetized to Stage 3 Plane 1 with aepromazine (2.2 mg/kg), ketamine (11mg/kg) and atropine sulfate (0.04 mg/kg) injected intramuscularly. Although anesthetized, the pigs still maintained key reflexes used to measure movement from Stage 3 Plane 2 to Stage 3 Plane 2 consciousness[5], specifically palpebral reflex.

Duration

Pig weight/age	5 seconds	10 seconds	15 seconds
<3days, <5 pounds	eliminated from trial	eliminated from trial	eliminated from trial
>3days, <5 pounds	11	11	11
>3days, >5 pounds	11	11	11
Total pigs	22	22	22

Assessment of depth and quality of the anesthesia included an evaluation of eye movement and location, deep pain response, and degree of muscle relaxation by a veterinarian. If an animal was deemed inadequately anesthetized, additional ketamine was administered. The same parameters (ECG, EEG, reflexes) were measured in Phase II of the study as Phase I.

Establish human safety

A multimeter (Amprove 33XR-A) was used to measure current to ensure that the unit would not activate unless the door was closed. Additionally, if the door was opened after activation of the unit the multimeter confirmed that the unit would turn off. However, for the purposes of this study, the safety device was disengaged so electrocutions could be videotaped and pigs could be observed before, during and after electrocution.

Reliability and repeatability

A record of successful euthanasia versus unsuccessful euthanasia was recorded. A successful euthanasia was defined as one in which a pig was electrocuted in one step that resulted in Stage 3 Plane 2 loss of consciousness and death. Deaths recorded as successful did not require euthanasia by injectable Pentobarbital.

Description of Quality Assurance/Quality Control Plan

Pigs were euthanized according to the guidelines established for electrocution by National Pork Board and AASV. Piglets in this trial were anesthetized to Stage 3 Plane 1 anesthesia because it is currently not recommended to euthanize piglets by electrocution if they are less than 10 pounds in weight. In this plane, palpebral responses remain present giving a measurable indicator of movement between Plane 1 and 2 of Stage 3 anesthesia. Loss of palpebral responses indicate a movement from Plane 1 to Plane 2 of Stage 3 anesthesia which is loss of consciousness deep enough for surgery. All activities were reviewed and approved by the Institutional Animal Care and Use Committee at the University of Illinois.

Results

Mechanical parameters for novel electrocution device

To measure consistency of pig placement in the device, the distance from the poll of the head to the cranial edge of the caudal tong was measured. When comparing pigs with positive and negative outcomes, there was no significant difference in this distance indicating that the pigs were placed in the device in a consistent location.

Table 1 examines the effect of caudal tong placement with respect to success rates. This caudal tong placement was variable based on the pigs weight and length. When measuring caudal tong placement with respect to death, there was one failure with the tong location at the 9-10th rib. There were multiple successes when the caudal tong was located both cranial and caudal to this rib location. This study indicated that if the tong is between the 2nd through the 12th rib, there is a 98.5% success rate in inducing death.

1. Tong placement (rib number) on death (for times 5, 10 and 15 seconds)

			Tong_Placement_Ribn										
			2 to 3	3 to 4	4 to 5	5 to 6	6 to 7	7 to 8	8 to 9	9 to 10	10 to 11	11 to 12	Total
Percent_ Successful	Successfull	Count	1	9	12	7	6	18	7	2	2	1	65
		% of Total	1.5%	13.6%	18.2%	10.6%	9.1%	27.3%	10.6%	3.0%	3.0%	1.5%	98.5%
	Non Successfull	Count	0	0	0	0	0	0	0	1	0	0	1
		% of Total	.0%	.0%	.0%	.0%	.0%	.0%	.0%	1.5%	.0%	.0%	1.5%
Total		Count	1	9	12	7	6	18	7	3	2	1	66
		% of Total	1.5%	13.6%	18.2%	10.6%	9.1%	27.3%	10.6%	4.5%	3.0%	1.5%	100.0%

Peak voltage was measured during each electrocution. Voltage was not significantly different between treatment groups, averaging 123.485 volts with a standard deviation of 0.827 volts.

One recording at the beginning of the study was measured to determine that the current was 60 hertz. This was not measured before each electrocution because it is generally accepted that electricity is supplied at 60 hertz in the United States.

Table 2.1 summarizes the mean amperage and standard deviation for both Phase I and Phase II of the trial. Additionally, there was no significant difference recorded between the various age and weight groups (Table 2.2).

2.1 Amperage variation according to success (Phase I and Phase II)

	Success	N	Mean	Std. Deviation
Amperage	Yes	92	0.614a	0.221
	No	4	0.641a	0.134

Different letters following values indicates differences with statistical significance (P≤0.05)

2.2 Amperage variations according to piglet category based on age and weight (Phase I & Phase II)

Category	N	Mean	Std. Deviation	Minimum	Maximum
< 3 Days/ < 5 Lbs	10	0.619a	.091	0.49	0.81
> 3 Days/ < 5 Lbs	43	0.602a	.198	0.19	1.21
> 3 Days/ > 5 Lbs	43	0.631a	.247	0.12	1.26
Total	96	0.617	.213	0.12	1.26

Different letters following values indicates differences with statistical significance (P≤0.05)

At the beginning of the trial, a multimeter (Amprove 33XR-A) was used to measure current to ensure that the unit would not activate unless the door was closed. Additionally, the door was opened after activation of the unit and the multimeter confirmed cessation of current.

Biological Parameters Measured to Establish that the Novel Electrocution Device Meets Standards of Humane Electrocution

In Phase I of the study, confirmation of loss of consciousness was measured. This was measured by electrocuting 5 pigs in each treatment group at 5 second duration of current and 3 second duration of current. Due to a lack of success at 5 seconds in the less than 3 days and less than 5 pounds group, all 10 pigs were electrocuted for 5 seconds to determine whether a Stage 3 Plane 2 loss of consciousness was consistently achievable.

3. Confirmation of loss of consciousness (Phase I)

			Loss_of_ Consciousness		
			Positive	Negative	Total
Age_Weight	< 3 Days/ < 5 Lbs	Count	7	3	10
		% of Total	70.0%	30.0%	100.0%
	> 3 Days/ < 5 Lbs	Count	10	0	10
		% of Total	100.0%	.0%	100.0%
	> 3 Days/ > 5 Lbs	Count	10	0	10
		% of Total	100.0%	.0%	100.0%
Total		Count	27	3	30
		% of Total	90.0%	10.0%	100.0%

The interval to Stage 3 Plane 2 loss of consciousness was determined. If an animal was confirmed to have this level of consciousness by a lack of reflexes at 5 seconds or 3 seconds, it can be assumed that the pig was at this level of consciousness sometime between the initiation of current and when the current ceased. The actual time to this level of consciousness cannot be confirmed but it is equal to or less than 3 seconds in the groups > 3 days and < 5 pounds and > 3 days and > 5 pounds

4. Reliability and Repeatability (Phase II)

There was a 98.5% success rate in inducing death in all pigs during the trial. There was one failure in a pig euthanized for 15 seconds at >3 days, <5 pounds. This pig was 4 days old.

4.1 Percentages of successful deaths by age/weight group with time frame 5 seconds (Phase II)

			Percent_Successful	
			Successfull	Total
Age_ Weight	> 3 Days/ < 5 Lbs	Count	11	11
		% of Total	100.0%	100.0%
	> 3 Days/ > 5 Lbs	Count	11	11
		% of Total	100.0%	100.0%
Total		Count	22	22
		% of Total	100.0%	100.0%

4.2 Percentages of successful deaths by age/weight group with time frame 10 seconds (Phase II)

			Percent_Successful	
			Successfull	Total
Age_ Weight	> 3 Days/ < 5 Lbs	Count	11	11
		% of Total	100.0%	100.0%
	> 3 Days/ > 5 Lbs	Count	11	11
		% of Total	100.0%	100.0%
Total		Count	22	22
		% of Total	100.0%	100.0%

4.3 Percentages of successful deaths by age/weight group with time frame 15 seconds (Phase II)

			Percent_Successful		
			Successfull	Non Successfull	Total
Age_ Weight	> 3 Days/ < 5 Lbs	Count	10	1	11
		% of Total	90.9%	9.1%	100.0%
	> 3 Days/ > 5 Lbs	Count	11	0	11
		% of Total	100.0%	.0%	100.0%
Total		Count	21	1	22
		% of Total	95.5%	4.5%	100.0%

4.4 Percentages Percentage of successful death by age/weight group (Phase II)

			Percent_Successful		
			Successfull	Non Successfull	Total
Age_ Weight	> 3 Days/ < 5 Lbs	Count	32	1	33
		% of Total	97.0%	3.0%	100.0%
	> 3 Days/ > 5 Lbs	Count	33	0	33
		% of Total	100.0%	.0%	100.0%
Total		Count	65	1	66
		% of Total	98.5%	1.5%	100.0%

10. Involuntary reflexes

Involuntary reflexes were measured during and after the euthanasia. Vocalization, tremors, and skin burns were very rare occurrences during the trial, occurring in 1 or less pigs. The most common reflexes were involuntary singular kicks and gasps.

10.1 Involuntary kick reaction break by piglet age/weight categories with time frame of 5, 10 and 15 seconds

			Kicking		
			No	Yes	Total
Age_ Weight	> 3 Days/ < 5 Lbs	Count	31	2	33
		% of Total	94.0%	6.0%	100.0%
	> 3 Days/ > 5 Lbs	Count	29	4	33
		% of Total	87.8%	12.2%	100.0%
Total		Count	60	6	66
		% of Total	90.9%	9.1%	100.0%

10.2 Gasp reaction break by piglet age/weight categories with time frame of 5, 10 and 15 seconds

			Gasping		
			No	Yes	Total
Age_ Weight	> 3 Days/ < 5 Lbs	Count	8	25	33
		% of Total	24.2%	75.8%	100.0%
	> 3 Days/ > 5 Lbs	Count	23	10	33
		% of Total	69.6%	30.4%	100.0%
Total		Count	31	35	66
		% of Total	47.0%	53.0%	100.0%

10.3 Involuntary kick reaction break by time frame with two piglets categories (> 3 Days < 5 pounds, > 3 days > 5 pounds)

			Kicking		
			No	Yes	Total
Time	5 Sec	Count	16	6	22
		% of Total	24.2%	9.1%	33.3%
	10 Sec	Count	22	0	22
		% of Total	33.3%	.0%	33.3%
	15 Sec	Count	22	0	22
		% of Total	33.3%	.0%	33.3%
Total		Count	60	6	66
		% of Total	90.9%	9.1%	100.0%

10.4 Gasp reaction break by time frame with two piglets categories (> 3 Days < 5 pounds, > 3 Days > 5 pounds)

			Gasping		
			No	Yes	Total
Time	5 Sec	Count	5	17	22
		% of Total	7.6%	25.8%	33.3%
	10 Sec	Count	13	9	22
		% of Total	19.7%	13.6%	33.3%
	15 Sec	Count	13	9	22
		% of Total	19.7%	13.6%	33.3%
Total		Count	31	35	66
		% of Total	47.0%	53.0%	100.0%

10.5 Gasp positive reaction break by piglet age/weight categories

Gasp Positive Reaction	Category		Test Proportion
	Over 3 Days/Under 5 lbs	Over 3 Days/Over 5 lbs	
Count	25 a	10 b	0.5
Percentage	75.8%	30.4%	
Total Individuals	33	33	

Different letters following values indicates different distributions with statistical significance based on the binomial test (P≤0.05)

10.6 Gasp reaction break by time frame 5, 10 and 15 seconds

Gasp Positive Reaction	Time frame			Test Proportion
	5 Seconds	10 Seconds	15 Seconds	
Count	17 a	9 b	9 b	0.5
Percentage	77.2%	40.9%	40.9%	
Total Individuals	22	22	22	

Different letters following values indicates different distributions with statistical significance based on the binomial test (P≤0.05)

10.7 Involuntary kick reaction break by time frame 5, 10 and 15 seconds

Kick Positive Reaction	Time frame			Test Proportion
	5 Seconds	10 Seconds	15 Seconds	
Count	6 a	0 b	0 b	0.5
Percentage	27.2%	0.0%	0.0%	
Total Individuals	22	22	22	

Different letters following values indicates different distributions with statistical significance based on the binomial test (P≤0.05)

10.8 Involuntary kick positive reaction break by piglet age/weight categories

Kick Positive Reaction	Category		Test Proportion
	Over 3 Days/Under 5 lbs	Over 3 Days/Over 5 lbs	
Count	2a	4a	0.5
Percentage	6.06%	12.12%	
Total Individuals	33	33	

Different letters following values indicates different distributions with statistical significance based on the binomial test (P≤0.05)

Discussion

Phase I of the study was designed to determine if electrocution could reliably induce unconsciousness in a rapid manner, thus proving humane euthanasia. All pigs > 3 days of age (> and < than 5 pounds) were reliably unconscious at Stage 3 Plane 2 at a 3 and 5 second duration of electrocution. This data indicates that electrocution is a humane method of euthanasia in pigs > 3 days of age when using this novel electrocution device.

There was a 70% success rate in inducing unconsciousness at a 5 second duration in pigs < 3 days of age and < 5 pounds. This data is consistent with the notion that the resistance around the skin can be less than that across the body, which causes the current to flow on the skin's surface rather than through the body[1]. That would explain why these pigs were still Stage 3 Level 1 conscious when the current was discontinued. Since we were unable to induce Stage 3 Level 2 unconsciousness reliably in pigs < 3 days and < 5 pounds, this group was removed from Phase II of the study.

This study indicates that electrocution of pigs > 3 days of age results in unconsciousness at <= to 3 seconds from the initiation of current. The key reflexes measured in the study to confirm Stage 3 Plane 2 loss of consciousness were pupil dilation, negative corneal reflex and negative nocioceptive reflexes. However, all pigs were anesthetized to Stage 3 Plane 1 in the trial because this method is not approved in pigs < 10 pounds of weight[1]. This did reduce the degree of measurable reflexes but reflexes were still present in the animals to assess the shift in the planes discernable when consciousness is lost, specifically from Plane 1 to Plane 2 in Stage 3 loss of unconsciousness.

The electroencephalogram was utilized to determine if brain activity could be an indication of unconsciousness. However, obtaining consistent readings and maneuvering of the pigs post electrocution made analysis of this data difficult and was not included.

Ohm's Law states that amperage (current) is equal to volts divided by resistance. Since volts are constant, the resistance of the pig will inversely affect the amperage recorded. The amperage was not statistically different between the 3 different age and weight categories. The average amperage for all pigs electrocuted in the trial was 0.617 amps with a standard deviation of 0.213. This average is above the recommendation of 0.5 amps by AASV and NPB for piglets greater than 10 pounds[1], however there were some pigs successfully euthanized with an amperage less than 0.5 amps. Further evaluation of resistance is needed to understand the minimum amperage required to successfully euthanize piglets.

Phase II of the study was designed to determine if electrocution could reliably induce death at various time intervals of current application. Electrocution euthanasia was successful in 98.5% of the pigs at all time

intervals. We feel, through our experience on farm, that this success rate would be very comparable to blunt force trauma or carbon dioxide euthanasia.

Caregiver well being during implementation and emotional response to the perception of the quality of death is an important consideration of the euthanasia method and design of this novel device. One of the disadvantages of electrocution euthanasia is that there is sudden stiffening and extension of the limbs, head, and neck[2]. This device is designed with a door that will block the caregiver's view of the pig during the electrocution and is also a safety feature. The other most common involuntary reflex observed that could affect a caregiver's well-being was involuntary singular gasps and occasional kicks. A longer duration of electrocution (10 and 15 seconds) reduced the incidence of gasps from 77% at 5 seconds to 41% at 10 seconds and involuntary kicks during the death process from 27% at 5 seconds to 0% at 10 seconds during the death process. Heavier pigs (>5 pounds) reduces gasping post electrocution from 76% to 30%.

This study indicates that electrocution using this novel device is a humane form of euthanasia when carried out in piglets greater than 3 days of age. Electrocution reliably induced unconsciousness at less than or equal to 3 seconds after the application of the current, except in pigs less than 3 days of age. Additionally, electrocution repeatedly induced death in piglets greater than 3 days of age at time periods equal to or greater than 5 seconds of current application. To reduce the incidence of involuntary gasps and kicks during the death process post electrocution, it would be recommended to electrocute pigs greater than 3 days of age for a duration of 10 seconds.

References

1. American Association of Swine Veterinarians and National Pork Board. 2008. *On-Farm Euthanasia of Swine-Recommendations for Producers,* Perry, IA.

2. American Veterinary Medical Association. 2007. *AVMA Guidelines on Euthanasia,* Schaumberg, IL.

3. Denicourt, M., Klopfenstein, C., Dufour, V., Pouliot, F., Labrecque, S., and D'Allaire, S. 2009. *On farm euthanasia: Efficient and safe (110 VAC) pig electrocution*. American Association of Swine Veterinarians.

4. Denicourt, M., Vachon P., D'Allaire, S., Batista, L. 2006. On Farm Euthanasia of Pigs by Electrocution – a Reliable, Human, and Economical method. Proceedings of the 19th IPVS Congress, Copenhagen, Denmark.

5. Canadian Council on Animal Care Module 11: Anesthesia, http://www.ccac.ca/en/CCAC_Programs/ETCC/Module11/09.html

Acknowledgements

This research was funded by the National Pork Checkoff.