On-Farm Euthanasia of Swine

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National Pork Board
Outline

- What is euthanasia
- Implications of euthanasia
- Importance of timeliness
- Available methods
- Confirming insensibility and death
- Ongoing efforts
Definition: euthanasia

“good death”
- Minimal pain and distress
- Rapid loss of consciousness
- Death achieved quickly and consistently
Definitions - death

Death: “Cessation of life”

- According to the Uniform Determination of Death Act (1981)

\[1\]

, an individual is dead if he/she has sustained either

1. irreversible cessation of circulatory and respiratory functions, or
2. irreversible cessation of all functions of the entire brain including brain stem

\[1\] Accepted by the American Medical Association, American Bar Association and is used in most States in US
Implications of Euthanasia

■ Impact on animals
  – Individual
  – Herd

■ Impact on employees

■ Who should perform euthanasia

■ Public perception/customer expectations
  – Companion animal perspective
  – Conflict of definition
Timeliness

Definition
- Inadequate or minimal prospect for improvement after 2 days of intensive care
- Severely injured and non-ambulatory pigs with the inability to recover
- Any pig immobilized with a BCS of 1

Causes for waiting
- Caretaker mentality
- Dislike of chosen method
Confirming death

- Cessation of respiration
  - Visual assessment can be difficult in final stages
    - mirror over mouth/nostrils

- Cessation of cardiac function
  - Heart beat will slow and become faint. There may be a phase where heart beat is detected, but involving fluttering, uncoordinated activity

- Cessation of all brain activity
  - Cessation of voluntary and reflexive behaviors
  - Cessation of electrical activity in the brain
Definitions – insensibility and unconsciousness

- Insensible: “Incapable or bereft of feeling or sensation”
  - Loss of consciousness
  - Lacking sensory perception or ability/power to react
  - Lacking emotional response
Confirming loss of consciousness or insensibility

- Loss of reflexive behaviors
  - Lack of “righting” response (midbrain)
  - Lack of eye blink response when corneal is touched (brain stem)
  - Lack of pupillary response to light (brain stem)
  - Lack of eye movement when icewater infused into ear (brain stem)
  - Lack of gag reflex to stimulation of trachea (brain stem)

- Unreliable indicators
  - Toe/tail pinch avoidance response (spinal reflex)
  - Back arch in response to touch (spinal reflex)
  - Rapid eye movements (nystagmus) can occur during both sensibility and insensibility, so is not a reliable measure of consciousness

Scientific measurements to assess “humane death”

- **Behavior**
  - (conscious) Struggling
  - Vocalizations (frequency, pitch)
  - Aversion tests

- **Physiologic**
  - Stress hormones (using blood draw or muscle)
  - Heart rate, Respiratory rate

- **Neurologic**
  - Brain activity
  - Post mortem analysis of traumatic brain injury
On-Farm Euthanasia Brochure

- Provides recommendations for on-farm euthanasia methods
- Now in English and Spanish
- Not necessarily all inclusive
- Mass depopulation not considered
<table>
<thead>
<tr>
<th>Method</th>
<th>Suckling pig (up to 12 lbs)</th>
<th>Nursery pig (up to 70 lbs)</th>
<th>Grower – Finisher pig (up to market weight)</th>
<th>Mature pig, sow or boar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon dioxide (CO₂)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes, but not practical†</td>
<td>Yes, but not practical†</td>
</tr>
<tr>
<td>Gunshot</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Penetrating captive bolt</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Non-penetrating captive bolt</td>
<td>Yes</td>
<td>Yes, with secondary step</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Electrocution, head-to-heart</td>
<td>Only for pigs over 10 lbs</td>
<td>Yes</td>
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<tr>
<td>Veterinarian administered anesthetic</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>administered anesthetic overdose</td>
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<tr>
<td>Blunt trauma</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
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</table>
Considerations When Choosing

- Human safety
- Pig welfare
- Practicality/Skill required.....
  - Training is very important
- Caretaker compliance
- Aesthetics
  - Blood discharge
  - Excitatory movement and vocalization
- Limitations...
  - 1 step vs 2 step
  - Proper equipment
  - etc
Anesthetic overdose

- Physiology – depression of the CNS → deep anesthesia → respiratory and cardiac arrest
- Practicality – must be performed by vet
- Disposal questions/concerns
  - Rendering
  - Scavenging
**Electrocution**

- **Head only**
  - Current must span the brain
  - Minimum of 3 seconds
  - MUST use secondary step within 15 seconds

- **Head to heart**
  - Current must travel diagonally through the body
  - Minimum of 15 seconds

- **NEVER only across the heart** (no insensibility)
Electrocution

- **Amperage (water volume)**
  - 0.5 amps for piglets over 10 lbs and nursery pigs up to 6 wks of age
  - 1.3 amps for pigs 6 wks of age and older

- **Voltage (water pressure)**
  - 110 volts for piglets over 10 lbs and nursery pigs up to 6 wks of age
  - 240 volts for pigs 6 wks of age and older

- Use “lock out-tag out” safety precautions

- NOT for use in piglets <10#
  - PI: Sarah Probst-Miller
Mechanical methods of swine euthanasia

- Concussive force
  - Blunt force trauma
  - Non-penetrating captive bolt
- Captive bolt
- Gunshot

Impact on the skull during mechanical euthanasia disrupts brain function by
  - Laceration of crushing of brain tissue
  - Shock waves producing axonal injury
  - Temporary cavitation

Loss of consciousness and death result from:
  - Traumatic brain injury
  - Brain hypoxia
  - Cerebral infarction
Brain injury and skull properties
Concussive - Blunt Force Trauma

- ONLY effective for suckling piglets
- Quick firm blow to the top of the head over the brain – with resolve
- Accuracy and resolve are ESSENTIAL
The Escalated Need for Alternatives

- The release of “undercover” videos (2007; 2008; 2009)
  - Consumers
  - Media
  - Producers

- New concern about federal or state animal welfare legislation that may not be based on sound scientific information.
**Captive Bolt – Non-penetrating**

- Mushroom or flat head

- Appropriate for
  - Suckling piglets = single step
  - Nursery pig = requires secondary step

- Placed firmly against the front of the head
Captive Bolt – Non-penetrating

Pictures courtesy of Jeff Hill
Captive Bolt – Non-penetrating

- Single fire
- Pneumatic
Pneumatic non-penetrating captive bolt gun for piglets ("Zephyr")

- Pneumatic nail gun was modified for euthanasia of rabbits (J. Rau)
- Widowski modified the design for piglet euthanasia
- Light-weight, quiet, does not require cartridges
- Air compressor
Zephyr vs. Blunt Force Trauma for suckling pig euthanasia

- Blunt force trauma was significantly better in terms of duration of limb movements (P<0.001)
- Blunt force trauma performed better in terms of duration of heart beat (P<0.001)
- 0/76 BFT piglets returned to sensibility vs. 13/99 for Z

All piglets were <24H old

The human factor

- Stockperson “c” was less successful in achieving skull fracture scores when using blunt force trauma (P<0.006),
  - differed from all other stockpersons using either method
- However, 0/9 piglets returned to sensibility with BFT vs. 5/10 with Z for this stockperson

Modified Zephyr project

**PI: Dr. Tina Widowski, U of Guelph**

- Effectiveness of the modified Zephyr on neonatal piglets (<72 hrs)
- Morbidity Score
  - General behaviour, diarrhea, dehydration, hind-leg weakness, temperature
- Reflex check
  - Corneal, pupillary light response, jaw tone, nose prick (repeat)
- Monitor convulsions: clonic → tonic
- Estimated time of death
  - No breathing, end of tonic convulsions
- Recorded time to full cardiac arrest

Effectiveness of non-penetrating captive bolt (Zephyr) and restraint for euthanasia of piglets from birth to 9 kg. Widowski, Millman, Lawliss. National Pork Board project
Damage Assessment

- Macroscopic scoring
  - Amount of damage
  - Location of damage

- CT Scans
  - Severity of fractures
  - Location of hemorrhage

- Pathology/Histology
  - Microscopic
  - Hemorrhage location
Neonatal Trial Results Overview

- All 100 piglets immediately insensible
- No return to consciousness
- Secondary step required for 5 piglets
  - Exsanguination
  - Maintained heart beat, neuromuscular spasms, or gasping
- Estimated time of death (ETOD)
  - End of tonic neuromuscular spasms
  - Average: 3 min 47 sec
- Moderate to severe macroscopic damage
- CT Scan and Pathology results to come
Questionnaire

- All 10 stock people completed individual questionnaire after euthanizing 10 piglets with Zephyr.
- Assess background in swine industry and euthanasia experience.
- Determine individual opinions of Zephyr effectiveness.
- Ten point scale → 1=ineffective : 10= highly effective.
- Average rating: 8.7 ± 1.6
Penetrating captive bolt

- Deliver injury to the brain without free projectile
  - Greater safety for handlers
- Acceptable method for all weight classes of pig >12 lbs
- Immediate secondary step (pithing or exsanguination) required by OIE and EU
  - In US, secondary step recommended for >100 lbs
- Blank cartridges or compressed air provide power, and retractable bolt varies for weight class of pig
Captive Bolt - Penetrating

- Correct positioning
- Proper equipment selection
- Equipment maintenance
Captive Bolt - Penetrating

- Correct positioning
  - ½ in. above eye-level
  - on the mid-line
  - aim toward tail
  - firmly against the skull

- Anatomy
  - Sinus
  - Face shape
Captive Bolt Guns

- Two types
  - Cylindrical
  - “Pistol”

- Equipment selection
  - Caliber
  - Cartridges/power
  - Bolt length
Captive Bolt - Penetrating

- Dept to brainstem
- 1step vs. 2 step process

Picture courtesy of Dr. Ramirez, ISU
Captive Bolt - Penetrating

Equipment Selection

- Kerner- Blitz – 2.25”
- KS - 3.35”
- KL - 5.31”

4.5”
Animal Responses

- Animal will lose voluntary muscle control and drop to ground

- Tonic phase
  - Stiffening, tetany

- Clonic phase
  - Rhythmic paddling of limbs
  - Can be violent and prolonged
  - Involuntary gasping may occur

- Loss of respiratory and cardiac functions
Proper maintenance critical to function and longevity of equipment

- Decrease bolt velocity
- Gun malfunction
On-going Research

- Use the Cash Euthanizer, new design with 3 bolt lengths, non-penetrating head, cartridges for all weight classes
  - Evaluate a single stage captive bolt euthanasia method
  - Determine the impact of employee attributes on their perceptions regarding the Cash Euthanizer system for on-farm euthanasia
Preliminary results

- Brain trauma scores are consistent with instantaneous loss of consciousness for most weight classes of pig
- Secondary step (exsanguination) was necessary for cessation of cardiac function in some of the mature sows and boars
- Non-penetrating head was too powerful for the suckling pigs, and has since been modified with new head and lesser charge
- On-farm trials with live pigs planned for Spring 2010 (Iowa)
Human safety – TOP PRIORITY

Approved method for all weight classes of pig >12 lbs

Immediate insensitivity and death as a result of direct damage to brain tissue from the projectile and secondary damage caused by displaced skull fragments
  - Damage depends on bullet velocity, tissue specific gravity, yaw (rotation)

Resultant wounds can be penetrating (enter brain cavity) or perforating (exit cranium)
  - Penetrating can result in only focal injury without loss of consciousness
**Gunshot Options**

- **Shotgun**
  - Slugs preferred over shot
    - Slugs have greater initial impact (~2400 ft lbs)
    - Shot has lower initial impact (~1600 ft lbs) but spreads after impact to cause greater secondary damage
  - 28 or 410 gauge for nursery only
  - 12, 16, or 20 gauge for grow/finish and mature sows and boars

- **Rim-fire rifle**
  - Minimum muzzle energy of 300 foot pounds (ft lbs)
  - Ammo – round nosed and solid preferred

- **Humane killer**
  - Purpose-made, single-shot gun
  - Chamfered muzzle and vented barrel = full contact

- **Handgun**
  - Lead round nose
  - Minimum muzzle energy of 300 foot pounds (ft lbs)
  - Recommended for pigs 400 lbs or less
Gunshot - Placement

- Muzzle should be held 2 to 10 inches from the pig’s skull

- Frontal position
  - \( \frac{1}{2} \) in. above eye-level
  - on the mid-line
  - aim toward tail

- Side position
  - behind the ear
  - Aim toward the opposite eye
Animal Responses

- Animal will lose voluntary muscle control and drop to ground

- Loss of respiratory and cardiac functions

- Depending on the location of brain trauma, tonic/clonic phases may occur
  - Tonic phase (Stiffening, tetany)
  - Clonic phase (Rhythmic paddling of limbs)
Gas

- Replacement of oxygen in the body
  - Onset of anesthesia – decrease of pH of CSF
  - Death due to respiratory arrest
- Acceptable method for all weight classes of pig
  - On-farm practicality is the limitation
- Several different gases available
  - Carbon Dioxide
  - Nitrogen
  - Argon
  - Mixture thereof and with oxygen and air
Carbon Dioxide

- 2 types
  - Pre-charge
  - Slow fill (20%)
    » (therefore ~10min to fill, then another 5min maintenance at 80-90% for death)

- Essential system elements
  - Dark “heavy duty” box – air tight seal w/lid
  - Inlet valve (bottom)
  - Outlet valve (top)
  - Regulator
  - Flow meter
  - Timer

Picture courtesy of Scanlon Daniels
Carbon Dioxide

- Potential problems
  - Empty gas container
  - Overcrowding the chamber
  - Gauges not used
    - Unregulated release of gas = poor welfare
    - Improper flow rate = lack of insensitivity or death
  - Inadequate exposure – need timer
  - Neonatal piglets = slowest breaths, so slowest to be euthanized
Animal Responses – 4 stages of anesthesia

- **Stage 1 – Induction**
  - Stage between initial administration and loss of consciousness. Progression from analgesia without amnesia to analgesia with amnesia.

- **Stage 2 – Excitation**
  - Stage following loss of consciousness and marked by excited and delirious activity. Respirations and heart rate may become irregular and there may be uncontrolled movements, vomiting, breath holding, and pupillary dilation.

- Guedel AE. Inhalation anesthesia, Ed 2, New York, 1951, Macmillan
Animal Responses – 4 stages of anesthesia

- **Stage 3 – Surgical anesthesia**
  - Stage where skeletal muscles relax and breathing becomes regular, eye movements slow, then stop and surgery can begin.

- **Stage 4 – Overdose**
  - Stage where too much medication has been given resulting in severe brain stem or medullary depression. Results in cessation of respiration and potential cardiovascular collapse.

- Guedel AE. Inhalation anesthesia, Ed 2, New York, 1951, Macmillan
On-going Research

- Evaluation of rate of administration of various gas mixtures using the Smart Box euthanasia device as a humane and effective method of piglet and nursery pig euthanasia. (PI: Chad Hagan; NPB Project)
  - Evaluate the effectiveness of CO$_2$ and CO$_2$/argon blend for euthanasia of suckling and early nursery pigs.
  - Evaluate the effects of rate of administration of CO$_2$, and a CO$_2$/argon blend on quality of euthanasia.
  - Determine potential interactions between gas blends and rate of gas administration.
On-going Research

- The use of different gases and gas combinations to humanely euthanize young suckling pigs (PI: Dr. Mhairi Sutherland; NPB Project)
  - Evaluate different gases and gas combinations (carbon dioxide, argon, and nitrogen) as a humane method to euthanize young suckling pigs
  - Evaluate the effectiveness of nitrous oxide as an anesthetic to reduce respiratory distress in young pigs euthanized with carbon dioxide, argon, or nitrogen gas
  - Validate the best management practices for euthanasia of young pigs established in objective 1 and 2 in a commercial swine farm setting
Secondary Steps

- Exsanguination

- Pithing
  - (#9 wire attached to dowel)
Confirming Insensibility and Death

- Insensibility (w/in 30s):
  - No rhythmic breathing
  - Dilated pupils
  - No righting reflex
  - No vocalization
  - No palpebral reflex
  - No response to pain

- Death (by 3min):
  - No breathing
  - No HR
  - No movement or muscle tone
  - No pain response
  - No vocalization
  - No corneal reflex
Ongoing Efforts

- On-farm Euthanasia Research
  - Funded 5 proposals:
    - 2 gas and gas mixtures
    - 2 mechanical (penetrating and non-penetrating cb)
    - 1 electricity
    - 1 novel – slow assent hypoxia (hypobaric chamber)

- Education/training materials

- Mass Depopulation
Thank You!!

- Dr. Suzanne Millman – Iowa State University
- Dr. Chad Hagan - Value-Added Science and Technologies (VI Booth #236)
- Alan Sucha – QC Supply (VI Booth #355)
- Dr. Tina Widowski – University of Guelph
Questions

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